

**Remedial Investigation/
Feasibility Study
for
Potential Source of Contamination 51**

**Naval Air Station Jacksonville
Jacksonville, Florida**



**Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO 0100**

September 2002

**Remedial Investigation/
Feasibility Study
for
Potential Source of Contamination 51**

**Volume I: Section 1.0 through 13.0
and References**

**Naval Air Station Jacksonville
Jacksonville, Florida**



**Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO 0100**

September 2002

**REMEDIAL INVESTIGATION/FEASIBILITY STUDY
FOR
POTENTIAL SOURCE OF CONTAMINATION 51

NAVAL AIR STATION JACKSONVILLE
JACKSONVILLE, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

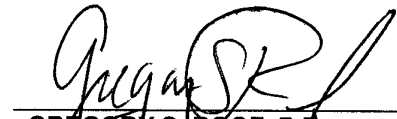
**Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406**

**Submitted by:
Tetra Tech NUS, Inc.
661 Anderson Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220**

**CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0100**

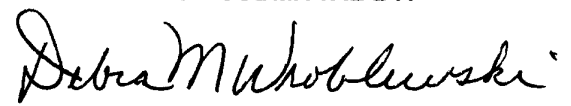
SEPTEMBER 2002

PREPARED UNDER THE SUPERVISION OF:



**GREGORY S. ROOF, P.E.
TASK ORDER MANAGER
TETRA TECH NUS, INC.
JACKSONVILLE, FLORIDA**


APPROVED FOR SUBMITTAL BY:



**DEBBIE WROBLEWSKI
PROGRAM MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA**



This document that describes the Remedial Investigation/Feasibility Study for Potential Source of Contamination 51, Naval Air Station Jacksonville, Jacksonville, Florida, has been prepared under the direction of a Florida-registered professional engineer. The work and professional opinions rendered in this report were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice.



Gregory S. Roe, P.E.
Professional Engineer Number PE050842
Tetra Tech NUS, Inc. Engineering Number 7988

Date: _____

9/6/02



FOREWORD

In order to meet its mission objectives, the United States Navy (Navy) performs a variety of operations, some requiring the use, handling, storage, or disposal of hazardous materials. Through accidental spills, leaks, and conventional methods of past disposal, hazardous materials may have entered the environment in ways unacceptable by today's standards. With growing knowledge of the long-term effects of hazardous materials on the environment, the Department of Defense (DoD) initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities.

One of these programs is the Navy and Marine Corps Installation Restoration Program (NIRP). This program complies with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act. The Acts, passed by Congress in 1980 and 1986, respectively, established the means to assess and clean up hazardous waste sites for both private-sector and Federal facilities. These Acts are the basis for what is commonly known as the Superfund program.

Originally, the Navy's part of this program was called the Navy Assessment and Control of Installation Pollutants (NACIP) Program. Early reports reflect the NACIP process and terminology. The Navy eventually adapted the program structure and terminology of the NIRP.

The NIRP is conducted in several stages:

- The Preliminary Assessment (PA) identifies potential sites through record searches and interviews.
- A Site Inspection (SI) then confirms which areas contain contamination, constituting actual sites. (Together, the PA and SI steps were called the Initial Assessment Study under the Navy's NACIP program.)

- Next, the Remedial Investigation and the Feasibility Study (RI/FS) together determine the type and extent of contamination, establish criteria for cleanup, identify and evaluate any necessary remedial action alternatives, and develop cost estimates of each alternative. As part of the RI/FS, a risk assessment will be made to identify potential effects on human health and the environment in order to help evaluate remedial action alternatives.
- The selected alternative is planned and conducted in the remedial design and remedial action stages. Monitoring then ensures the effectiveness of the effort.

The investigation of potential hazardous waste sites at Naval Air Station (NAS) Jacksonville in Jacksonville, Florida is presently being conducted under the NIRP and follows CERCLA guidelines. Earlier preliminary investigations had been conducted at NAS Jacksonville, under the Navy's NACIP program. In 1990, in coordination with the United States Environmental Protection Agency (USEPA) and the Florida Department of Environmental Protection (FDEP), the investigation of hazardous waste sites was formalized under a Federal Facilities Agreement (FFA).

NAS Jacksonville is conducting the investigation and cleanup of hazardous waste sites at their facility by working through the Southern Division Naval Facilities Engineering Command. USEPA and the FDEP oversee the Navy environmental program. All aspects of the program are conducted in compliance with State and Federal regulations, as ensured by the participation of these regulatory agencies.

Questions regarding the NIRP Program at NAS Jacksonville should be addressed to Mr. Tim Curtin at (904) 542-2717 extension 120.

TABLE OF CONTENTS

PROFESSIONAL ENGINEER AUTHORIZATION.....	iii
FOREWORD.....	v
ACRONYMS AND ABBREVIATIONS.....	xiv
EXECUTIVE SUMMARY.....	ES-1
1.0 INTRODUCTION	1-1
1.1 RI/FS APPROACH AND OBJECTIVES.....	1-1
1.2 REPORT SCOPE AND ORGANIZATION.....	1-3
2.0 SITE BACKGROUND	2-1
2.1 SITE CHARACTERIZATION.....	2-1
2.1.1 Location and Description.....	2-1
2.1.2 NAS Jacksonville History.....	2-4
2.1.3 PSC 51 History	2-4
2.2 ENVIRONMENTAL SETTING.....	2-6
2.2.1 Geography, Demographics, and Land Use	2-6
2.2.2 Physiography and Topography	2-6
2.2.3 Climate.....	2-8
2.2.4 Soil	2-8
2.2.5 Regional Geology	2-8
2.2.6 Site Specific Geology	2-9
2.2.7 Regional Hydrology.....	2-9
2.2.8 Site Hydrology	2-14
3.0 PREVIOUS SITE INVESTIGATIONS AND REMEDIAL ACTIONS.....	3-1
3.1 RADIOLOGICAL INVESTIGATION MEMORANDUMS (BEI).....	3-1
3.2 SAMPLING EVENT REPORT (HARDING LAWSON ASSOCIATES).....	3-2
3.2.1 Surface Soil.....	3-2
3.2.2 Subsurface Soil	3-7
3.2.3 Groundwater.....	3-7
3.2.4 Surface Water.....	3-9
3.2.5 Focused Risk Evaluation (FRE).....	3-9
3.3 REMOVAL ACTION AT PSC 51 (BEI).....	3-14
3.4 ADDITIONAL RADIOLOGICAL GROUNDWATER SAMPLING ACTIVITIES (BEI)	3-19
3.5 QUARTERLY GROUNDWATER SAMPLING ACTIVITIES	3-24
4.0 RI/FS FIELD PROGRAM	4-1
4.1 OBJECTIVE AND APPROACH.....	4-1
4.1.1 DPT Well Installation.....	4-2
4.1.2 Hollow-stem Auguring Well Installation.....	4-6
4.1.3 Monitoring Well Development	4-7
4.1.4 Groundwater Level Measurements.....	4-8
4.1.5 Monitoring Well Groundwater Sampling.....	4-8
4.1.6 Surface Water Sampling.....	4-10
4.1.7 Sediment Sampling.....	4-10
4.1.8 Surface Soil Sampling	4-10
4.1.9 Groundwater DPT Sampling with Mobile Laboratory Analysis	4-11
5.0 NATURE AND EXTENT OF CONTAMINATION.....	5-1
5.1 SOURCES OF CONTAMINATION.....	5-1
5.1.1 Fire Fighter Training Area.....	5-2
5.1.2 Former Waste Oil Disposal Area	5-2
5.2 BACKGROUND SCREENING CONCENTRATIONS	5-2
5.3 CONTAMINATION ASSESSMENT.....	5-3

5.3.1	Surface Soil	5-3
5.3.2	Surface Water.....	5-15
5.3.3	Sediment	5-16
5.3.4	Groundwater.....	5-17
6.0	CONTAMINANT FATE AND TRANSPORT	6-1
6.1	POTENTIAL ROUTES OF MIGRATION.....	6-1
6.2	CONTAMINANT PERSISTENCE AND FATE.....	6-3
6.2.1	Processes.....	6-3
6.2.2	Persistence, Fate and Transport of PSC 51 Specific Contaminants	6-6
6.3	SUMMARY OF NATURAL ATTENUATION RESULTS	6-7
6.3.1	Dissolved Oxygen.....	6-12
6.3.2	Dissolved Carbon Dioxide/Alkalinity.....	6-13
6.3.3	Nitrogen/Orthophosphate	6-14
6.3.4	Dissolved Iron/Ferric Iron/Ferrous Iron and Manganese.....	6-15
6.3.5	Sulfate/Sulfide	6-15
6.3.6	Oxidation-Reduction Potential.....	6-16
6.3.7	Methane/Ethene/Ethane.....	6-17
6.3.8	pH	6-18
6.3.9	Specific Conductivity	6-19
6.3.10	Chloride	6-19
6.3.11	Temperature	6-19
6.3.12	Initial Scoring of NA Conditions at PSC 51	6-20
7.0	BASELINE HUMAN HEALTH RISK ASSESSMENT.....	7-1
7.1	DATA EVALUATION	7-2
7.1.1	Data Usability	7-2
7.1.2	Selection of COPCs.....	7-4
7.2	EXPOSURE ASSESSMENT	7-17
7.2.1	Exposure Setting	7-17
7.2.2	Conceptual Site Model	7-19
7.2.3	Potential Exposure Pathways.....	7-21
7.2.4	Quantification of Exposure	7-30
7.3	TOXICITY ASSESSMENT	7-36
7.3.1	Carcinogenic Effects	7-39
7.3.2	Noncarcinogenic Effects.....	7-41
7.4	RISK CHARACTERIZATION	7-42
7.4.1	Methodology for Estimation of Quantitative Risks.....	7-42
7.4.2	Results of the Risk Characterization	7-45
7.4.3	Risks Associated with Additional Soil Samples.....	7-49
7.4.4	Risks Associated with Additional Groundwater Samples.....	7-50
7.5	UNCERTAINTY ANALYSIS	7-50
7.5.1	Uncertainty in Selection of COPCs	7-51
7.5.2	Uncertainty in the Exposure Assessment	7-53
7.5.3	Uncertainty in the Toxicological Evaluation.....	7-54
7.5.4	Uncertainty in the Risk Characterization	7-57
7.6	REMEDIAL GOAL OPTIONS.....	7-57
7.7	SUMMARY OF HUMAN HEALTH RISK ASSESSMENT	7-58
8.0	SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT (ERA)	8-1
8.1	PROBLEM FORMULATION.....	8-1
8.1.1	Environmental Setting	8-1
8.1.2	Contaminant Fate and Transport	8-4
8.1.3	Ecotoxicity and Potential Receptors.....	8-5
8.2	COMPLETE EXPOSURE PATHWAYS	8-6
8.3	ASSESSMENT AND MEASUREMENT ENDPOINTS	8-7
8.4	TOXICITY EVALUATION	8-8

8.4.1	Toxicity Screen.....	8-8
8.4.2	Food Chain Toxicity.....	8-11
8.5	EXPOSURE ESTIMATE	8-14
8.6	RISK CALCULATION.....	8-17
8.6.1	Volatile Organic Compounds.....	8-19
8.6.2	Semivolatile Organic Compounds.....	8-22
8.6.3	Metals.....	8-24
8.7	UNCERTAINTY	8-27
8.7.1	Uncertainty in Problem Definition.....	8-28
8.7.2	Uncertainty in the Exposure Assessment	8-28
8.7.3	Uncertainty in the Ecological Effects Characterization.....	8-28
8.7.4	Uncertainty in the Risk Characterization	8-29
8.8	SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	8-29
9.0	DESCRIPTION OF THE FS	9-1
9.1	THE FS PROCESS	9-1
9.2	REMEDIAL CONSIDERATIONS.....	9-3
10.0	REMEDIAL ACTION OBJECTIVES	10-1
10.1	ARARs.....	10-1
10.1.1	Chemical-Specific ARARs.....	10-1
10.1.2	Location -Specific ARARs	10-14
10.1.3	Action-Specific ARARs.....	10-14
10.1.4	TBC Criteria.....	10-14
10.2	IDENTIFICATION OF RAOs	10-15
10.2.1	RAOs for Soil.....	10-15
10.2.2	RAOs for Surface Water.....	10-19
10.2.3	RAOs for Groundwater.....	10-21
10.2.4	RAO for Sediment	10-25
10.2.5	Summary of RAOs.....	10-26
10.3	ESTIMATED AREAL EXTENT AND VOLUME OF CONTAMINATED MEDIA	10-26
10.4	GENERAL RESPONSE ACTIONS	10-28
11.0	SCREENING OF REMEDIAL TECHNOLOGIES AND DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES	11-1
11.1	PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS	11-2
11.2	DETAILED SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS	11-7
11.2.1	No Action	11-7
11.2.2	Limited Action.....	11-7
11.2.3	Removal	11-9
11.2.4	In-situ Treatment	11-10
11.2.5	Ex-situ Treatment.....	11-10
11.3	SELECTION OF REPRESENTATIVE PROCESS OPTIONS FOR SOIL.....	11-12
11.4	PRELIMINARY SCREENING OF SURFACE WATER TECHNOLOGIES AND PROCESS OPTIONS.....	11-13
11.5	PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS	11-13
11.6	DETAILED SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS	11-19
11.6.1	No Action	11-19
11.6.2	Limited Action.....	11-20
11.6.3	Removal	11-23
11.6.4	In-situ Treatment	11-24
11.6.5	Ex-situ Treatment	11-28
11.6.6	Disposal.....	11-35

11.7	SELECTION OF REPRESENTATIVE PROCESS OPTIONS FOR GROUNDWATER	11-37
11.8	SUMMARY OF RETAINED REMEDIAL TECHNOLOGIES ASSEMBLED INTO REMEDIAL ALTERNATIVES	11-37
12.0	DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES.....	12-1
12.1	DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR SURFACE SOIL	12-3
12.1.1	Alternative S-1:No Action	12-3
12.1.2	Alternative S-2:Limited Action	12-4
12.1.3	Alternative S-3:Excavation and Disposal	12-7
12.2	DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER.....	12-11
12.2.1	Alternative GW-1:No Action	12-11
12.2.2	Alternative GW-2:Monitored NA	12-13
12.2.3	Alternative GW-3:Enhanced Biodegradation	12-17
12.2.4	Alternative GW-4:In-situ Chemical Oxidation	12-22
12.2.5	Alternative GW-5:Extraction-and-Treatment	12-26
12.2.6	Alternative GW-6:Air Sparging	12-31
13.0	COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES.....	13-1
13.1	COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SURFACE SOIL.....	13-1
13.1.1	Comparison of Threshold Criteria	13-1
13.1.2	Comparison of Primary Balancing Criteria	13-5
13.2	COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER	13-5
13.2.1	Comparative Analysis of Remedial Alternatives for Groundwater at PSC 51	13-5
13.2.2	Comparison of Threshold Criteria	13-6
REFERENCES		R-1
<u>APPENDICES</u>		
APPENDIX A USGS INFORMATION.....		A-1
APPENDIX B SURVEY DATA		B-1
APPENDIX C SOIL BORING LOGS WELL COMPLETION RECORDS		C-1
APPENDIX D MONITORING WELL DEVELOPMENT RECORDS		D-1
APPENDIX E FIELD DATA FORMS		E-1
APPENDIX F VALIDATED LABORATORY DATA PACKAGES		F-1
APPENDIX G MOBILE LABORATORY DATA.....		G-1
APPENDIX H FIELD NATURAL ATTENUATION SHEETS.....		H-1
APPENDIX I STATISTICAL ANALYSIS SURFACE SOILS		I-1
APPENDIX J SUPPORTING INFORMATION FOR HUMAN HEALTH RISK ASSESSMENT		J-1
APPENDIX K ECOLOGICAL RISK ASSESSMENT INFORMATION.....		K-1
APPENDIX L FEASIBILITY STUDY DESIGN CALCULATIONS		L-1
APPENDIX M FEASIBILITY STUDY COST CALCULATIONS		M-1

TABLES

NUMBER	PAGE
3-1	Surface Soil Detections Exceeding FDEP Criteria, Fire Fighter Training Area.....3-4
3-2	Surface Soil Detections Exceeding FDEP Criteria, Oil Disposal Area.....3-5
3-3	Groundwater Detections Exceeding Regulatory Criteria, Fire Fighter Training Area3-8
3-4	Groundwater Detections Exceeding Regulatory Criteria, Oil Disposal Area.....3-10
3-5	Summary of Hydrocone Groundwater Detections.....3-11
3-6	Detections in BEI Post-Excavation Soil Samples Exceeding Regulatory Criteria, Fire Fighter Training Area.....3-17
3-7	Detections in BEI Post-Excavation Soil Samples Exceeding Regulatory Criteria, Oil Disposal Area.....3-20
4-1	Water Table Elevation Data4-9
5-1	TtNUS Surface Soil Analytical Detections Summary, Oil Disposal Area5-4
5-2	TtNUS Surface Soil Analytical Detections Summary, Fire Fighter Training Area.....5-9
5-3	TtNUS DPT/Mobile Laboratory Groundwater Analytical Detections Summary.....5-18
5-4	TtNUS Replicate Groundwater Analytical Detections Summary – Organic Constituents.....5-28
5-5	TtNUS Groundwater Analytical Detections Summary – Organic Constituents.....5-29
5-6	Mobile Laboratory Frequency and Range of Organic Compound Detections in Groundwater...5-34
5-7	Frequency and Range of Organic Compound Detections in Groundwater from Monitoring Wells.....5-35
5-8	TtNUS Groundwater Analytical Detections Summary – Inorganic Constituents.....5-36
5-9	Frequency and Range of Inorganic Compound Detections in Groundwater5-39
6-1	Field Results for Natural Attenuation.....6-8
6-2	Laboratory Analytical Results for Natural Attenuation.....6-10
6-3	Natural Attenuation Scoring6-21
7-1	Screening Criteria Used In Selection of COPCs7-6
7-2	Occurrence, Distribution, and Selection of Chemicals of Potential Concern, Direct Contact with Surface Soil.....7-8
7-3	Occurrence, Distribution, and Selection of Chemicals of Potential Concern, Migration from Soil to Air7-10
7-4	Occurrence, Distribution, and Selection of Chemicals of Potential Concern, Migration from Soil to Groundwater.....7-11
7-5	Occurrence, Distribution, and Selection of Chemicals of Potential Concern, Direct Contact with Groundwater7-12
7-6	Occurrence, Distribution, and Selection of Chemicals of Potential Concern, Direct Contact with Surface Water7-15
7-7	Occurrence, Distribution, and Selection of Chemicals of Potential Concern, Direct Contact with Sediment.....7-16
7-8	Chemicals Retained as COPCs for Quantitative Evaluation In Human Health Risk Assessment.....7-18
7-9	Conceptual Site Model and Selection of Exposure Pathways7-25
7-10	Exposure Point Concentrations.....7-29
7-11	Summary of Exposure Input Parameters7-31
7-12	Parameters for Evaluation of Dermal Contact with Groundwater7-37
7-13	Cancer Toxicity Data – Oral/Dermal.....7-40
7-14	Non-Cancer Toxicity Data – Oral/Dermal.....7-43
7-15	Summary of Cancer Risks and Hazard Indices7-46
7-16	Remedial Goal Options for Soil7-59
7-17	Remedial Goal Options for Groundwater7-60
8-1	Selection of Chemicals of Preliminary Concern – Surface Soil.....8-9
8-2	Selection of Chemicals of Preliminary Concern – Surface Water.....8-12
8-3	Selection of Chemicals of Preliminary Concern – Sediment.....8-13
8-4	Selection of Chemicals of Preliminary Concern – Groundwater8-15
8-5	Acute Surface Soil Guidelines.....8-20
8-6	Hazard Quotients for Ecological Receptors8-26

TABLES (Continued)

10-1	Synopsis of Federal and State ARARs and Guidance Materials for PSC 51.....	10-2
10-2	Summary of Exceedances of ARARs/TBCs for Surface Soil	10-17
10-3	Summary of Exceedances of ARARs/TBCs for Groundwater	10-24
10-4	Summary of Remedial Action Objectives for PSC 51.....	10-26
11-1	Preliminary Screening of Technologies and Process Options for Soil.....	11-3
11-2	Preliminary Screening of Technologies and Process Options for Groundwater	11-14
12-1	Factors for Detailed Analysis of Remedial Alternatives	12-2
13-1	Comparative Analysis of Contaminated Soil Remedial Alternatives Against the Seven Criteria	13-2
13-2	Comparative Analysis Summary of Groundwater Alternatives	13-9
13-3	Milestone Objectives for Alternative GW-2 (Natural Attenuation)	13-12

FIGURES

<u>NUMBER</u>		<u>PAGE</u>
2-1	Facility Location Map.....	2-2
2-2	Site Location Map.....	2-3
2-3	Site Map.....	2-5
2-4	1993 USGS Topographic Map.....	2-7
2-5	Geologic Cross-Section Line Location Map.....	2-10
2-6	Geologic Cross-Section A-A'	2-11
2-7	Geologic Cross-Section B-B'	2-12
2-8	Groundwater Elevation Contour Map December 13, 1999.....	2-15
2-9	Groundwater Elevation Contour Map October 2, 2001.....	2-16
3-1	HLA Sampling Locations	3-3
3-2	Bechtel Sampling Locations and Areas of Soil Excavation.....	3-15
4-1	TtNUS RI Sampling Locations	4-3
4-2	Groundwater, Surface Water, and Sediment RI Sampling Locations.....	4-4
4-3	RI DPT Locations.....	4-5
5-1	Soil Analytical Results Exceeding Applicable Regulatory-ODA	5-12
5-2	Soil Analytical Results Exceeding Applicable Regulatory Criteria FFTA	5-13
5-3	Benzene Groundwater Plume Exceeding FDEP GCTLs (Aerial View)	5-41
5-4	Benzene Groundwater Plume Exceeding FDEP GCTL (3-D View)	5-42
5-5	Ethylbenzene Groundwater Plume Exceeding FDEP GCTLs (Aerial View)	5-43
5-6	Ethylbenzene Groundwater Plume Exceeding FDEP GCTL (3-D View)	5-44
5-7	Toluene Groundwater Plume Exceeding FDEP GCTLs (Aerial View).....	5-45
5-8	Toluene Groundwater Plume Exceeding FDEP GCTL (3-D View)	5-46
5-9	Total Xylenes Groundwater Plume Exceeding FDEP GCTLs (Aerial View).....	5-47
5-10	Total Xylenes Groundwater Plume Exceeding FDEP GCTL (3-D View)	5-48
5-11	TCE Groundwater Plume Exceeding FDEP GCTLs (Aerial View).....	5-49
5-12	TCE Groundwater Plume Exceeding FDEP GCTL (3-D View).....	5-50
5-13	CIS 1,2-DCE Groundwater Plume Exceeding FDEP GCTLs (Aerial View)	5-51
5-14	CIS 1,2-DCE Groundwater Plume Exceeding FDEP GCTL (3-D View).....	5-52
5-15	Vinyl Chloride Groundwater Plume Exceeding FDEP GCTLs (Aerial View).....	5-53
5-16	Vinyl Chloride Groundwater Plume Exceeding FDEP GCTL (3-D View).....	5-54
5-17	Naphthalene Groundwater Plume Exceeding FDEP GCTLs (Aerial View).....	5-55
5-18	Naphthalene Groundwater Plume Exceeding FDEP GCTL (3-D View).....	5-56
5-19	Inorganic Constituent Concentrations Exceeding FDEP GCTLs in Groundwater Samples	5-58
7-1	Summary of Human Health Risk Assessment Process.....	7-3
7-2	Conceptual Site Model	7-20
8-1	Eight Step Ecological Risk Assessment Process for Superfund.....	8-2

FIGURES (Continued)

10-2	Estimated Extent of Surface Soil Contamination	10-29
12-1	Proposed Locations of Injection for Chemical Oxidation, Chemical Oxidation Alternative	12-24
12-2	Proposed Locations of Groundwater Extraction Wells, Extraction and Treatment Alternative	12-27
12-3	Proposed Location of Sparge Points, Air Sparging Alternative.....	12-33

ACRONYMS AND ABBREVIATIONS

ABB-ES	ABB Environmental Services
ARARs	Applicable or Relevant and Appropriate Requirements
AS	Air Sparging
BCF	Bioconcentration Factor
BEI	Bechtel Environmental, Inc.
BHC	Benzene Hexachloride
bls	Below Land Surface
BTEX	Benzene, Toluene, Ethylbenzene, and Total Xylenes
CSFs	Cancer Slope Factors
CERCLA	Comprehensive Environmental Response, Compensation and Liabilities Act
CO ₂	Carbon Dioxide
COCs	Contaminants of Concern
COPCs	Chemicals of Potential Concern
cpm	Curies per Meter
CTO	Contract Task Order
°C	Degrees Celsius
°F	Degrees Fahrenheit
DCE	Dichloroethene
DIC	Dissolved Inorganic Carbon
DO	Dissolved Oxygen
DPT	Direct Push Technology
DQO	Data Quality Objective
DRMO	Defense Reutilization Marketing Office
Eh	Oxidation Reduction Potential of Groundwater
ERA	Ecological Risk Assessment
EPC	Exposure Point Concentration
FAC	Florida Administrative Code
FDA	Food and Drug Administration
FDEP	Florida Department of Environmental Protection
FFA	Federal Facilities Agreement
FFTA	Fire Fighting Training Area
FOTW	Federally Owned Treatment Works
FRE	Focused Risk Evaluation
FS	Feasibility Study
FSP	Field Sampling Plan

ACRONYMS AND ABBREVIATIONS (Cont'd)

FSPQAPPA	Field Sampling Plan and Quality Assurance Project Plan Addendum
ft	Feet/Foot
ft/d	Foot (or feet) Per Day
ft/y	Foot (or feet) Per Year
ft ²	Square Feet/Foot
GAC	Granular Activated Carbon
GCTLs	Groundwater Cleanup Target Levels
GGC	Groundwater Guidance Concentration
gpm	Gallons per Minute
GRAs	General Response Actions
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HLA	Harding Lawson Associates
HQ	Hazard Quotient
ILCR	Incremental Lifetime Cancer Risk
IM	Interim Measure
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
lbs	Pounds
LDRs	Land Disposal Restrictions
LOAEL	Lowest-Observed-Adverse-Effect-Level
LUCIP	Land Use Control Implementation Plan
MCL	Maximum Contaminant Level
mg/cm ²	Milligrams per Square Centimeter
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
MOA	Memorandum of Agreement
mph	Miles Per Hour
msl	Mean Sea Level
mS/cm	Microsiemens per Centimeter
mV	Millivolts
MW	Monitoring Well
NA	Natural Attenuation
NAS	Naval Air Station

ACRONYMS AND ABBREVIATIONS (Cont'd)

NAT	Navy Aviation Trades
Navy	United States Navy
NCEA	National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NIRP	Naval Installation Restoration Program
NOAEL	No-Observed-Adverse-Effect-Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTU	Nephelometric Turbidity Unit
ODA	Oil Disposal Area
O&M	Operation and Maintenance
ORNL	Oak Ridge National Laboratory
ORP	Oxydation-Reduction Potential
OU	Operable Unit
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
pCi/L	PicoCuries per Liter
pCi/g	PicoCuries per Gram
ppt	Parts Per Thousand
PRBs	Permeable Reactive Barriers
PQL	Practical Quantitation Limit
PRGs	Preliminary Remediation Goals
PSC	Potential Source of Contamination
PVC	Polyvinyl Chloride
PWC	Public Works Center
RAGS	Risk Assessment Guidance for Superfund
RAOs	Remedial Action Objectives
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RfDs	Reference Doses
RGOs	Remedial Goal Options
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure

ACRONYMS AND ABBREVIATIONS (Cont'd)

ROD	Record of Decision
ROI	Radius of Influence
SAF	South Antenna Field
SARA	Superfund Amendments and Reauthorization Act of 1986
SAV	Secondary Acute Value
SCG	Soil Cleanup Goal
SCTL	Soil Cleanup Target Level
SCV	Secondary Chronic Value
SER	Sampling Event Report
SLERA	Screening-level Ecological Risk Assessment
SMDP	Scientific/Management Decision Point
SOUTHNAVFACENGCOM	Southern Division, Naval Facilities Engineering Command
SPLP	Synthetic Precipitation Leaching Procedure
SQAG	Sediment Quality Assessment Guidelines
SSFP	Scoping Study Field Program
SSLs	Soil Screening Levels
SSW	Site Screening Workplan
SVOCs	Semivolatile Organic Compounds
SWQs	Surface Water Quality Standards
TAL	Target Analyte List
TBC	To Be Considered
TCE	Trichloroethene or Trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TKN	Total Kjeldahl Nitrogen
TtNUS	Tetra Tech NUS, Inc.
UCL	Upper Confidence Limit
µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter
USDA	United States Department of Agriculture
EPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
UV/OX	Ultraviolet Light and Oxidation

ACRONYMS AND ABBREVIATIONS (Cont'd)

VE	Vapor Extraction
VOCs	Volatile Organic Compounds
yd ³	Cubic Yard

EXECUTIVE SUMMARY

This Remedial Investigation/Feasibility Study (RI/FS) Report for Potential Source of Contamination (PSC) 51, Naval Air Station (NAS) Jacksonville, Florida has been prepared by Tetra Tech NUS, Inc. (TtNUS) for the Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 100. This report describes the field investigation and subsequent findings of the Remedial Investigation (RI) at PSC 51, the risk analyses and findings from the human health and ecological risk assessments, and an evaluation of various remedial alternatives.

This Executive Summary provides a brief summary of the information presented in the combined RI/FS document. It also summarizes the results of each of the four major portions of the report.

ES.1 INTRODUCTION

The United States Navy (Navy) implemented the Navy Installation Restoration Program (NIRP) to investigate and remediate releases of hazardous materials at Navy and Marine Corps installations. The NAS Jacksonville Partnering Team (Partnering Team), established in 1993, guides the implementation of the NIRP at NAS Jacksonville.

A formal Data Quality Objective (DQO) process was not being used during this point in the Partnering Team's history. However, a scoping meeting was conducted by the Partnering Team to plan the RI field activities. During this meeting, the team evaluated the previous actions at the site and their results and developed the scope of work completed during this project. The objectives of the RI/FS were to develop an understanding of the geologic and hydrogeologic setting at PSC 51, define the aerial extent of impact to the media of concern, evaluate the potential natural attenuation pathways, conduct human health and ecological risk assessments, and evaluate and recommend remedial alternatives that may achieve a final remedy for the site.

ES.2 NAS JACKSONVILLE AND PSC 51 DESCRIPTION AND HISTORY

NAS Jacksonville is located in southeastern Duval County, Florida and is located approximately nine miles south of downtown Jacksonville. NAS Jacksonville was placed on the United States Environmental Protection Agency's (USEPA) National Priority List (NPL) of Superfund Sites in December 1989 because of documented past release of hazardous waste at the facility.

NAS Jacksonville was commissioned on October 15, 1940 to provide facilities for pilot training and a Navy Aviation Trades School for ground crewmen. With the advent of World War II, the physical size of NAS Jacksonville more than doubled, and military functions supported the war effort. The station became the headquarters for the Chief of Naval Operational Training, the final training phase before fleet assignment. The operational areas of the station still maintained coastal protection with seaplanes. The facility reached a peak of 42,000 naval personnel and 11,000 civilians by 1946.

PSC 51 is located in the western portion of the South Antenna Field (SAF) slightly north of the southern perimeter of NAS Jacksonville. PSC 51 is comprised of two areas including a former Fire Fighting Training Area (FFTA) and a former waste Oil Disposal Area (ODA). During preliminary investigations, the ODA was described as a circular area approximately 50 feet (ft) in diameter north of the patrol road at the southern boundary of the base and west of Allegheny Road. The ODA was used to drain aircraft of hydraulic fluids, fuels, and oils prior to the aircraft being relocated to the Defense Reutilization Marketing Office (DRMO) located across Highway 17 (Roosevelt Boulevard) from NAS Jacksonville (BEI, 1999). The FFTA was described as a nearly circular area approximately 60 ft in diameter, located approximately 250-ft northwest of the ODA. This area was formerly used by the base fire department as a practice fire fighting training area.

Previous investigations associated with the station's IR program had been performed and reported by ABB Environmental Services (ABB-ES) and Harding Lawson Associates (HLA). Bechtel Environmental, Inc. (BEI) performed preliminary radiological sampling, an interim action and groundwater monitoring for radiological parameters. The previous site activities identified radiological and chemical contamination of the soil and groundwater at PSC 51. An interim remedial action was performed to remove soils identified with radiological and lead contamination.

ES.3 GEOLOGY AND HYDROGEOLOGY

The PSC 51 site geology is characterized by fine to medium grained unconsolidated sands encountered from the ground surface to depths varying from 2 to 4 ft below land surface (bls). Below the sand, a sandy clay unit was encountered to an approximate depth of 6 ft bls followed by silty sand to a depth of approximately 50 ft bls. A clay unit was encountered at 50 ft bls to a depth of greater than 70 ft bls.

Three aquifer systems have been identified in the Jacksonville area including the surficial aquifer, intermediate aquifer consisting of permeable units within the Hawthorn formation, and the Floridan aquifer system. During this RI, we encountered only the surficial aquifer, which was saturated from approximately 4 ft bls to approximately 50 ft bls. Groundwater flow was calculated at 0.15 ft per day (ft/d)

or 54.75 ft per year (ft/y) toward the southeast using general information provided by the United States Geologic Survey (USGS).

ES.4 NATURE AND EXTENT OF CONTAMINATION

Based on previous investigations and sampling efforts, and the interim remedial actions, the Partnering Team focused the RI on surface soil (only near the southeastern portion of the ODA excavation), groundwater, surface water, and sediments. The RI was further focused on only potential chemical contamination, since previous excavations and sampling had shown that radiological contamination was not a concern for this investigation. Limited sampling was performed to verify the removal of surface soil impacted by metals. Surface water and sediment sampling performed in an unnamed creek located downgradient of PSC 51 was performed to determine if the contaminated groundwater had affected these media. Due to previous evidence of groundwater contamination, additional groundwater sampling was performed to identify the nature and extent of groundwater contamination.

In the RI report for Operable Unit (OU) 1 at NAS Jacksonville, ABB-ES basewide background concentrations for the various media were established. No site specific background sampling was performed for this RI. Instead, the basewide concentrations were used for comparison purposes.

Surface soil samples were collected from around the former FFTA and former ODA during the RI effort and analyzed for Target Analyte List (TAL) metals only. In these, 18 inorganics were detected in the surface soil. Arsenic and vanadium were the only constituents that exceeded regulatory criteria at the former ODA. Aluminum, antimony, arsenic, barium, copper, iron, lead, mercury, nickel, and vanadium exceed regulatory criteria at the former FFTA. Of these, only lead and arsenic exceeded their Florida Department of Environmental Protection (FDEP) industrial Soil Cleanup Target Levels (SCTLs). Statistical analysis was used to evaluate the surface soil data set against the FDEP industrial SCTLs. This analysis reported 95 percent upper confidence values less than the FDEP industrial SCTLs.

Surface water and sediment samples were collected from three positions in the unnamed creek, and analyzed for Target Compound List (TCL) volatile organic compounds (VOCs). The VOC detected in one surface water and one sediment sample was 2-butanone, a common laboratory artifact. This constituent was detected in a different location for each media and was reported as an estimated value in both instances.

Groundwater samples were collected from DPT borings and analyzed with a mobile laboratory. In addition, groundwater samples were collected from 14 monitoring wells, and analyzed for TCL VOCs, TCL semivolatile organic compounds (SVOCs), and TAL Metals at the fixed-based laboratory. During the

mobile laboratory event, samples from the same wells were analyzed for select VOCs. VOC contaminants were detected in the groundwater samples from wells near the center of the ODA excavation toward the unnamed creek, except for one carbon disulfide detection nearer the FFTA. Seventeen VOCs were detected in the groundwater; however only benzene, 1,2-dichloroethene (DCE), trichloroethene (TCE), and vinyl chloride exceeded Florida Groundwater Cleanup Target Levels (GCTLs). Total xylenes was detected in one sample at its GCTL. Three SVOC contaminants, 2,4-dimethylphenol, 2-methylnaphthalene and naphthalene, were detected in the groundwater in one well with only naphthalene detected in one other well. Naphthalene and 2-methylnaphthalene were detected at concentrations exceeding GCTLs. Four polynuclear aromatic hydrocarbons (PAHs), naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, and indeno(1,2,3-cd)pyrene, were detected in the groundwater samples and only naphthalene exceeded its GCTL. Nineteen inorganic constituents were detected in the groundwater samples collected from PSC 51. Of these, only the concentrations of three analytes (aluminum, iron and manganese) exceeded GCTLs. They were less than their respective basewide background concentrations however.

The detections of each constituent appear to form a definitive plume, with concentrations decreasing downgradient and near the lateral boundaries. The two SVOCs exceeding GCTLs increased between the 1997 and 1999 sampling events. In addition, the groundwater is discharging into the unnamed creek, which appears to drain the area to the St. Johns River.

ES.5 FATE AND TRANSPORT

The contaminants of concern (COCs) and media that are affected were identified in the Nature and Extent, Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) sections. Their fate in the subsurface and processes by which they might be transported through the environment are reported in this section. Since the COCs are predominantly VOCs, a natural attenuation evaluation of PSC 51 was performed.

The results of natural attenuation sampling at PSC 51 indicate that anaerobic conditions prevail in the co-mingled benzene and chlorinated solvent plume. The production of 1,2-DCE and vinyl chloride, breakdown products of the TCE starting material, indicates that reductive dechlorination is active within the plume. Inorganic species analyses suggest that sulfate reduction is active in the core of the plume. Anaerobic destruction of benzene is very inefficient; however, its slow aerobic degradation consumes dissolved oxygen and helps maintain anaerobic conditions within the co-mingled plume, a prerequisite for reductive dechlorination of TCE.

Anaerobic conditions at the site, while favoring reductive dechlorination of TCE may inhibit the biological destruction of less chlorinated breakdown products (e.g., 1,2-DCE, vinyl chloride). As part of ongoing monitoring it will be imperative to evaluate any increases in the concentrations of the breakdown products and consider localized introduction of oxygen in the downgradient portion of the plume.

ES.6 HUMAN HEALTH RISK ASSESSMENT

An HHRA was performed for PSC 51 and evaluated the detected contaminants. Future construction workers, current/future maintenance workers, future occupational workers, current/future adult and adolescent trespassers, and hypothetical future on-site residents were evaluated as potential receptors. Inhalation of ambient air, direct contact with surface soil and sediment, direct contact with groundwater via ingestion, dermal contact, and inhalation, and direct contact with surface water in unnamed stream were evaluated as potential exposure pathways. Based on the evaluation and under the limitations defined in the uncertainty analyses. The HHRA identified the following potentially adverse conditions for PSC 51:

- Incremental lifetime cancer risks for all receptors exposed to soil were less than or within USEPA's target cancer risk range of 10^{-4} to 10^{-6} . Although incremental lifetime cancer risks for the occupational worker, child resident, and adult resident were above FDEP's target risk level of 1×10^{-6} , arsenic was the only chemical in soil with cancer risks greater than 1×10^{-6} .
- The incremental lifetime cancer risks for the hypothetical future child resident exposed to groundwater exceeded FDEP's target cancer risk level of 1×10^{-6} . The incremental lifetime cancer risks for the hypothetical future adult resident exposed to groundwater exceeded USEPA's target cancer risk range and FDEP's target cancer risk level. Benzene, 1,1-DCE, and vinyl chloride were the main contributors to the cancer risk in groundwater.

ES.7 ECOLOGICAL RISK ASSESSMENT

An ERA was performed to evaluate potential receptors including soil-dwelling organisms, terrestrial plants, sediment-dwelling organisms, pelagic/planktonic organisms, aquatic plants, and organisms that ingest the aforementioned. The ERA summarized the following:

- The metals concentrations may be harming plants and soil organisms that reside at PSC 51, but should not pose a significant risk to wildlife, especially when the lack of suitable habitat at the site is considered.

- There is considerable uncertainty regarding whether the groundwater-to-sediment/surface water pathway is complete for PSC 51. For chemicals measured in surface water and sediment with known toxicity, risk levels are low.
- Recommendations for PSC 51 depend in part on potential future uses. Maintained as it is now, the site does not appear to warrant further action.

ES.8 FEASIBILITY STUDY (FS)

The purpose of the FS is to identify remedial action objectives (RAOs), identify and evaluate remedial action alternatives that will achieve those objectives, and evaluate the alternatives that best meet the evaluation criteria. The FS portion of this document contains three RAOs that were developed from the RI and risk assessment processes. Remedial technologies that address site-specific considerations established in the RAOs are identified and screened. The technologies that pass the screening phase are developed into remedial alternatives, which are developed and evaluated in detail for comparison in the comparative analysis.

The specific RAOs are listed below:

- RAO 1: Protect human health by eliminating or preventing exposure to COCs in soil.
- RAO 2: Protect human health and the environment by preventing potential exposure to COPCs in surface water.
- RAO 3: Reduce human health risk associated with exposure to groundwater at PSC 51 due to various organic compounds (e.g., 1,1-DCE, benzene, and vinyl chloride).
- RAO 4: Reduce groundwater contamination at PSC 51 to meet chemical-specific applicable or relevant and appropriate requirements (ARARs).

Alternatives considered for surface soil contamination (RAO 1) were no action, limited action, and excavation and off-site disposal. Alternatives considered for groundwater at PSC 51 included no action, natural attenuation, enhanced biodegradation, chemical oxidation, extraction and treatment, and air sparging.

The evaluation of alternatives was completed on seven of the nine criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The seven criteria considered were

overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; short-term effectiveness; and implementability. The eighth and ninth criteria, State and Public Acceptance, will be addressed for PSC 51 once comments on this document and the Proposed Plan are received.

Based on the FS, Tables ES-1 and ES-2 document the final alternatives considered and the associated time and cost estimates for each alternative for soil and groundwater.

Table ES-1 Soil Remediation Alternatives Feasibility Study, PSC 51 Naval Air Station Jacksonville Jacksonville, Florida			
Alternative Number	Alternative	Time Until RAOs are Achieved	Cost
S-1	No Action	30 yr ¹	\$0
S-2	Limited Action	30 yr ¹	\$101,000
S-3	Excavation and Off-site Disposal	1 yr	\$615,000

¹ Thirty (30) years was chosen for this alternative based on Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) guidance.

Table ES-2 Groundwater Remediation Alternatives Feasibility Study, PSC 51 Naval Air Station Jacksonville Jacksonville, Florida			
Alternative Number	Alternative	Time Until RAOs are Achieved	Cost
GW-1	No Action	30 yr ¹	\$0
GW-2	Natural Attenuation	15 yr	\$384,000
GW-3	Enhanced Biodegradation	5 yr	\$600,000
GW-4	Chemical Oxidation	2 yr	\$813,000
GW-5	Extraction and Treatment	8 yr	\$1,003,000
GW-6	Air Sparging	5 yr	\$736,000

The FS recommended Alternative Number S-2 to achieve the RAO for surface soil in the most cost-effective fashion. It further recommends that if the land use changes to a residential scenario in the future, alternative remedial technologies such as Alternative Number S-3 should be considered. It also recommends Alternative Number GW-2 as a feasible and cost effective alternative for remediation of the groundwater.

1.0 INTRODUCTION

TtNUS, under contract to the Department of the Navy, SOUTHNAVFACENGCOM, conducted an RI/FS for PSC 51 at NAS Jacksonville located in Jacksonville, Duval County, Florida. This RI/FS has been completed in accordance with contract number N62467-94-D-0888 (CTO 100) as part of the Naval Aviation Trades (NIRP). The activities and findings for the RI/FS are presented and discussed in this report.

The Navy has identified potential areas where hazardous materials have been released to the environment at NAS Jacksonville. Fifty-two PSCs have been identified at NAS Jacksonville, one of which is PSC 51. PSC 51 is also OU 5 at NAS Jacksonville. NAS Jacksonville was listed on the CERCLA NPL in December 1989 because of documented past release of hazardous waste at the facility.

The Navy implemented the NIRP to investigate and remediate releases of hazardous materials at Navy and Marine Corps installations. The Partnering Team, established in 1993, guides the implementation of the NIRP at NAS Jacksonville. This team consists of representatives from the USEPA, the FDEP, SOUTHNAVFACENGCOM and its consultants, and NAS Jacksonville.

1.1 RI/FS APPROACH AND OBJECTIVES

Activities required under CERCLA regulations for NAS Jacksonville are being conducted under the Federal Facilities Agreement (FFA) and the base's Installation Restoration Program (IRP). An integral portion of this program is the NAS Jacksonville Partnering Team, which is comprised of representatives from NAS Jacksonville, SOUTHNAVFACENGCOM, the USEPA, the FDEP, and contractors to SOUTHNAVFACENGCOM for this work. Under this arrangement, the Partnering Team makes decisions that guide the activities at each of the CERCLA sites.

The results of preliminary sampling at PSC 51 (performed prior to this RI) indicated that the ODA and the FFTA were impacted by organic and inorganic contaminants. There were also radiological concerns identified at PSC 51 prior to this RI. As a result, the site was directed to undergo a RI as part of the CERCLA process.

During the time between the preliminary sampling and this RI, the radiological concerns were investigated and an interim measure (IM) was performed by BEI to remove the radiologically-contaminated soil. The radiological survey and soil removal action documentation is provided in The Completion Report for the PSC 51 South Antenna Area (BEI, 1999). This interim action eliminated the soil radiological issues from the site. Post-excavation groundwater sampling has been performed since that time to verify that

the groundwater does not have radiological contamination that must be addressed in the RI. Based on these efforts the NAS Jacksonville Partnering Team decided that radiological issues would not be considered as part of the RI activities.

The preliminary sampling effort screened both soil and groundwater for the CERCLA list of contaminants [e.g., TCL VOCs, TCL pesticides and polychlorinated biphenyls (PCBs), TCL SVOCs, TAL Metals]. During the confirmation sampling associated with the IM, soil and groundwater samples were analyzed for inorganic and organic contaminants. The results of these activities indicated that there was the potential for lead impact to surface soils along the southeastern edge of the excavation performed by BEI, and that groundwater in the area was impacted by organics. The Partnering Team chose to consider groundwater, surface soils, surface water and sediments during the RI.

A formal DQO process was not used at this point in the Partnering Team's history. However, a scoping meeting was conducted by the Partnering Team to plan the RI field activities. The following was decided at this meeting and issued in a message to Martha Berry of the USEPA for concurrence:

- Four surface soil samples would be collected from a 25-ft grid pattern along the southeast edge of the excavation. These samples would be analyzed for TAL metals only.
- Subsurface soil would not be a media of concern. Therefore, no subsurface soil samples would be collected.
- Sediment and surface water from a small unnamed creek, which is located to the south of PSC 51, would be sampled. Surface water and sediment samples from three specified sampling points were to be collected during the RI. These samples were to be analyzed for TCL VOCs only.
- Groundwater was determined to be impacted during previous investigations. Nine new wells were to be installed at locations selected during this meeting and those nine along with four existing monitoring wells (MW-2, MW-4, MW-5 and MW-6) were to be sampled and analyzed for TCL VOCs and SVOCs and TAL metals.

Radiological impacted soils had been removed and based on groundwater samples analyzed prior to this meeting, radiological analyses of groundwater would not be performed. The information collected during this investigation was combined with the results of the earlier assessment activities to produce the draft RI/FS report.

The draft RI/FS for PSC 51 was issued to the Partnering Team in October 2000, for review. After the review of the draft RI/FS, the Partnering Team agreed that additional data collection was necessary. The additional field activities included the following:

- Collection of additional surface soil samples at PSC 51 to define surface soil arsenic contamination in excess of residential levels at PSC 51 and to determine concentrations of TAL metal constituents in surface soil near the FFTA at PSC 51.
- Install an up-gradient well closer to MW-04.
- Define the vertical extent and horizontal extent at depth of groundwater contamination at PSC 51 near MW-04 and previous hydrocone sampling locations. In addition, define the horizontal extent in deeper intervals of the aquifer.
- Define the downgradient limits of the shallow groundwater contaminant plume. Assist the USGS in a determination of whether the groundwater from this area discharges into the unnamed creek that flows south of PSC 51 and to the community south of the station.

The objectives of the RI/FS are as follows:

- Develop an understanding of the geologic and hydrogeologic setting at PSC 51.
- Define the aerial extent of impact to the media of concern.
- Collect Natural Attenuation (NA) parameters and evaluate the potential NA pathways.
- Identify the chemicals of potential concern (COPCs) for the risk assessment process.
- Conduct human health and ecological risk assessments.
- Evaluate and recommend remedial alternatives that may achieve a final remedy for the site.

1.2 REPORT SCOPE AND ORGANIZATION

This report documents the results from the current field RI program and also presents data from previous activities at PSC 51. This report includes analytical results from previous investigations and also summarizes their findings and conclusions. Furthermore, it incorporates these reports by reference to provide a comprehensive record of the investigative activities at PSC 51.

This report contains the following 14 sections:

- 1.0 Introduction, overview of the RI/FS approach and objectives, background information, and the scope and organization of the report.
- 2.0 Site background, location, descriptions, history of PSC 51, and physical characteristics of the region and PSC 51, including climate, soil, geology, and hydrogeology.
- 3.0 Previous site investigations and remedial actions.
- 4.0 RI/FS Field Program a summary of the activities conducted for this remedial investigation.
- 5.0 Nature and extent of all contamination within each environmental media. Evaluation of the fate and transport of contaminants.
- 6.0 Contaminant fate and transport, including an evaluation of NA processes. Summary of NA Results.
- 7.0 HHRA.
- 8.0 ERA.
- 9.0 Description of the FS process.
- 10.0 Identification of the remedial action objectives.
- 11.0 Identification and screening of remedial technologies and development of remedial alternatives.
- 12.0 Detailed analysis of the remedial alternatives for surface soil and groundwater.
- 13.0 Comparative analysis of the remedial alternatives.

References.

2.0 SITE BACKGROUND

2.1 SITE CHARACTERIZATION

The following sections provide an historical overview of the NAS Jacksonville facility and a site-specific background for PSC 51. Background information on the geography and demographics, physiography and topography, climate, soil, regional geology, and regional hydrogeology are summarized in Section 3.0.

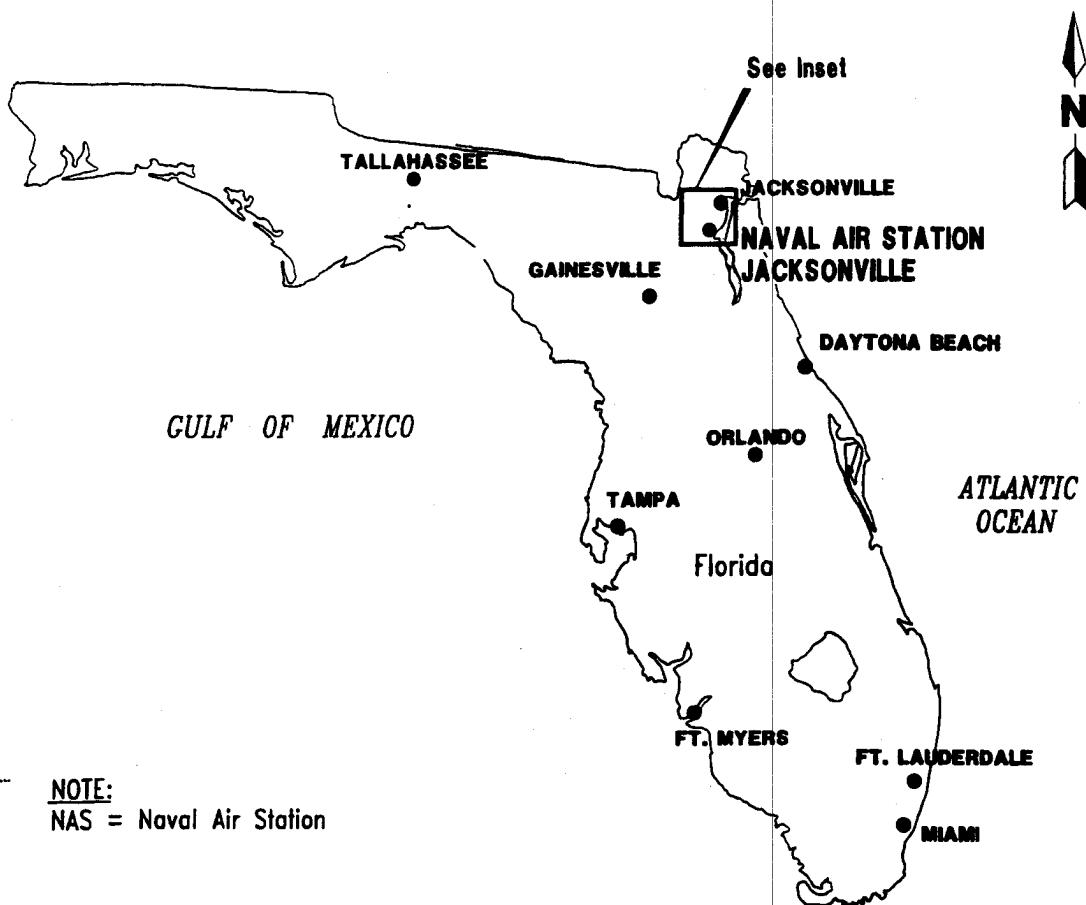
2.1.1 Location and Description

NAS Jacksonville occupies approximately 3,896 acres in southeastern Duval County, Florida and is located approximately nine miles south of downtown Jacksonville. The facility is located on the St. Johns River approximately 24 miles upstream from its confluence with the Atlantic Ocean. The main portion of NAS Jacksonville is bordered to the north by the Timaquana Country Club, to the east and northeast by the St. Johns River, to the south by a residential area, and to the west by Highway 17 (Roosevelt Boulevard), with Westside Regional Park, commercial developments, and other NAS Jacksonville operations beyond. The location of NAS Jacksonville is presented in Figure 2-1. The location of PSC 51 on NAS Jacksonville is presented on Figure 2-2, Site Location Map.

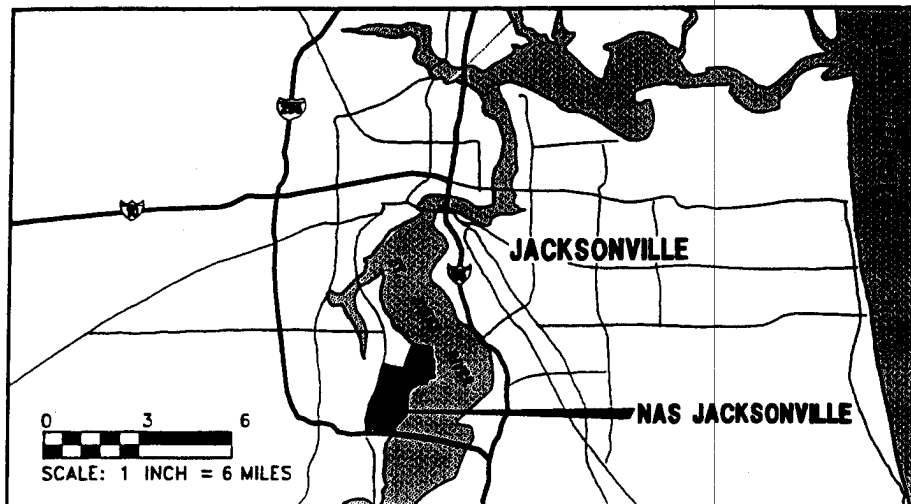
NAS Jacksonville is a multi-mission base hosting more than 100 tenant commands and employing more than 26,000 active duty and civilian personnel. The installation is home to the P-3C Orion long-range maritime surveillance aircraft, the SH-60F Seahawk helicopter, and the S-3B Viking jet aircraft. The Naval Aviation Depot, located on NAS Jacksonville, is the largest industrial employer in northeast Florida and performs maintenance, repair and overhaul of Navy aircraft.


In addition to the many operational squadrons flying P-3, C-12, C-9 aircraft, and SH-60F helicopters, NAS Jacksonville is home to Patrol Squadron Thirty (VP-30), the Navy's largest aviation squadron and the only "Orion" Fleet Replacement Squadron that prepares and trains U.S. and foreign pilots, air crew and maintenance personnel for further operational assignments.

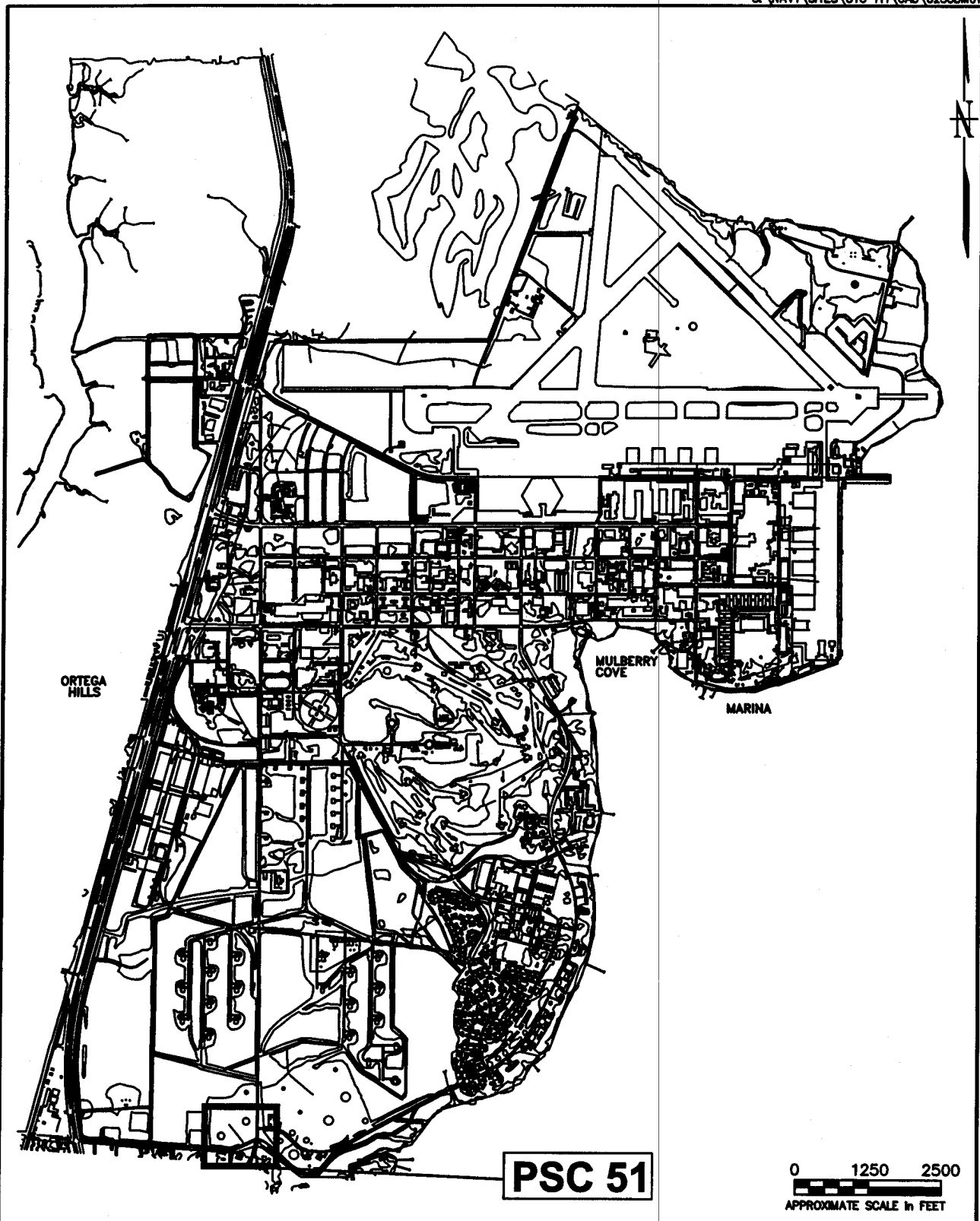
Support facilities include an airfield for pilot training, a maintenance depot employing more than 150 different trade skills capable of performing maintenance as basic as changing a tire to intricate micro-electronics or total engine disassembly, a hospital, a Fleet Industrial Supply Center, a Navy Family Service Center, and recreational facilities.




NOTE:
NAS = Naval Air Station



DRAWN BY LLK	DATE 6/13/00	 <p>FACILITY LOCATION MAP PSC 51 NAVAL AIR STATION JACKSONVILLE JACKSONVILLE, FLORIDA</p>	CONTRACT NO. 0253	
CHECKED BY	DATE		APPROVED BY	DATE
COST/SCHED-AREA			APPROVED BY	DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE 2-1	REV. 0



DRAWN BY CW	DATE 7/13/00		SITE LOCATION MAP PSC 51 NAS JACKSONVILLE JACKSONVILLE, FLORIDA		CONTRACT NO. N0253	
CHECKED BY	DATE				APPROVED BY DATE	
COST/SCHED-AREA					APPROVED BY DATE	
SCALE AS NOTED					DRAWING NO. FIGURE 2-2	REV. 0

FOI

2.1.2 NAS Jacksonville History

NAS Jacksonville was commissioned in on October 15, 1940 to provide facilities for pilot training and a Naval Aviation Trades (NAT) School for ground crewmen. With the advent of World War II, the physical size of the NAS Jacksonville more than doubled, and military functions supported the war effort. During 1942, the Navy phased out pilot training, and the station became the headquarters for the Chief of Naval Operational Training, the final training phase before fleet assignment. The NAT School became the Naval Air Technical Training Center under the Chief of Naval Air Technical Training, NAS Memphis. The operational areas of the station still maintained coastal protection with seaplanes. The facility reached a peak of 42,000 naval personnel and 11,000 civilians by 1946.

At the conclusion of World War II, NAS Jacksonville was devoted entirely to aviation training. In 1945, Chief of Naval Operational Training was redesignated Chief Naval Air Advanced Training. In July 1946, the Seventh Naval District was transferred from Miami, Florida to the NAS Jacksonville facility, as joint command with Chief Naval Air Advanced Training. On April 5, 1948, the Navy transferred the Chief Naval Air Training and all training facilities to NAS Corpus Christi, Texas.

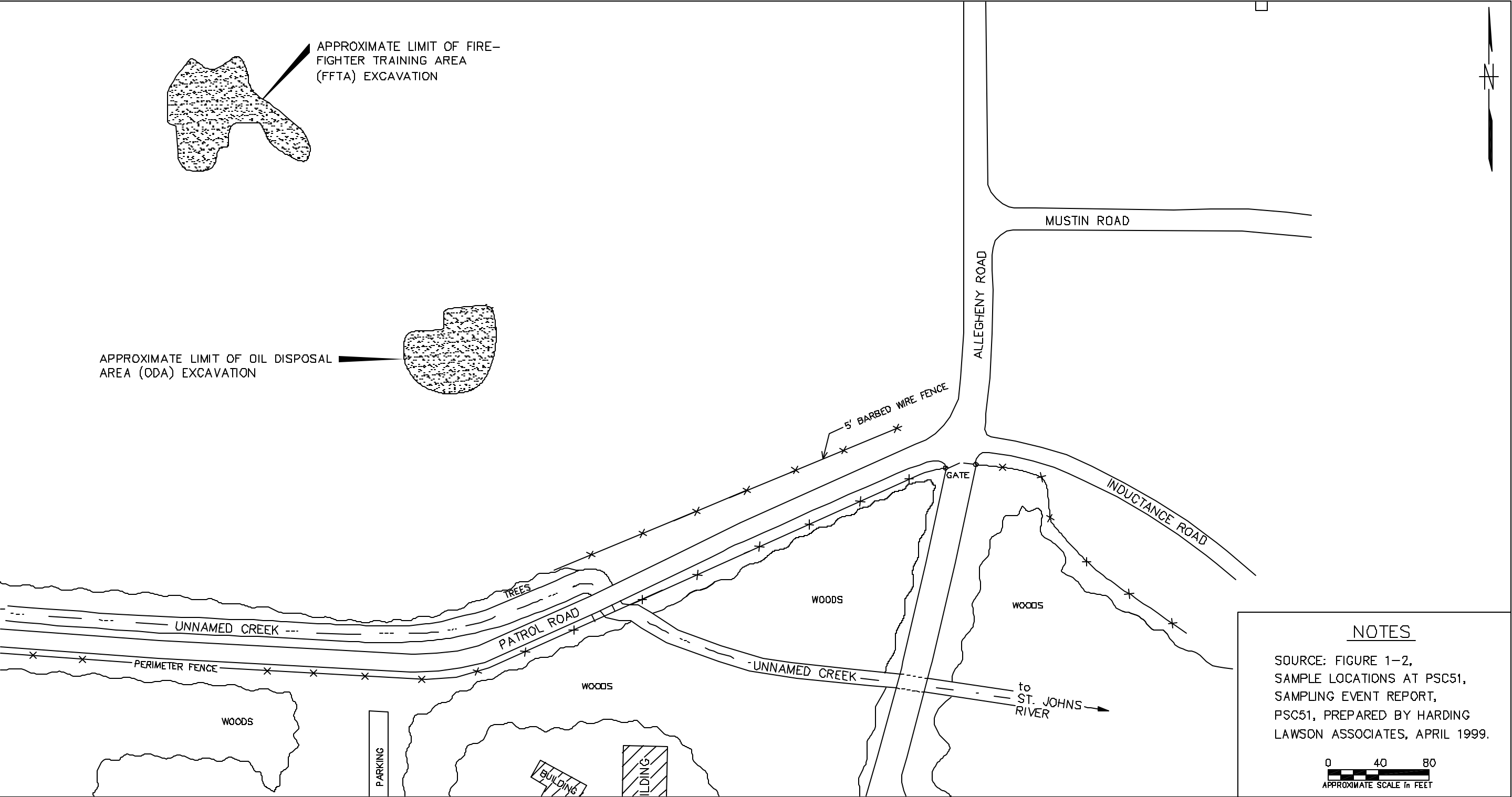
By January 1949, NAS Jacksonville's mission was to support the operational carrier squadrons with fleet squadrons assigned to Commander, Naval Air Bases, Sixth District and patrol squadrons assigned to Combat Patrol Wing Eleven. On January 1, 1951, the Navy reactivated the Naval Air Technical Training Center and Marine Air Division activities in support of the Korean build-up of facilities. This joint operational and training status continues to this time.

2.1.3 PSC 51 History

PSC 51 is located in the western portion of the SAF slightly north of the southern perimeter of NAS Jacksonville. PSC 51 is comprised of two areas including a former FFTA and a former ODA. The PSC 51 site map is presented as Figure 2-3. A brief summary of each are discussed below.

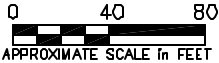
2.1.3.1 Fire Fighter Training Area

The FFTA was a nearly circular area approximately 60 ft in diameter. It was located north of the patrol road, which parallels the southern boundary of the base, and west of Allegheny Road approximately 250 ft northwest of the ODA. This area was formerly used by the base fire department as a practice FFTA. Previous reports indicate that this area was identifiable by its barren soil and by debris such



NOTES

SOURCE: FIGURE 1-2,
SAMPLE LOCATIONS AT PSC51,
SAMPLING EVENT REPORT,
PSC51, PREPARED BY HARDING
LAWSON ASSOCIATES, APRIL 1999.



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY	DATE
LLK	5/9/02
CHECKED BY	DATE
COST/SCHED-AREA	
SCALE	
AS NOTED	



SITE MAP
PSC 51
NAS JACKSONVILLE
JACKSONVILLE, FLORIDA

CONTRACT NO.	N0253
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO.	FIGURE 2-3
REV.	0

as shards of glass and metal scattered throughout. The area has since been excavated and backfilled and is no longer easily identified.

2.1.3.2 Former Waste Oil Disposal Area

The ODA is a circular area approximately 50 ft in diameter and is located north of the patrol road and west of Allegheny Road. It is located southeast of the FFTA. Mr. Roy Durham, a former public works department employee at NAS Jacksonville, reported that the ODA was operational from 1946 until 1952 (HLA, 1999a). The ODA was used to drain aircraft of hydraulic fluids, fuels, and oils prior to the aircraft being relocated to the DRMO located across Highway 17 (Roosevelt Boulevard) from NAS Jacksonville (BEI, 1999). Previous reports indicate that this area was identifiable by its barren soil; however, the area has since been excavated and backfilled and is no longer easily identified.

2.2 ENVIRONMENTAL SETTING

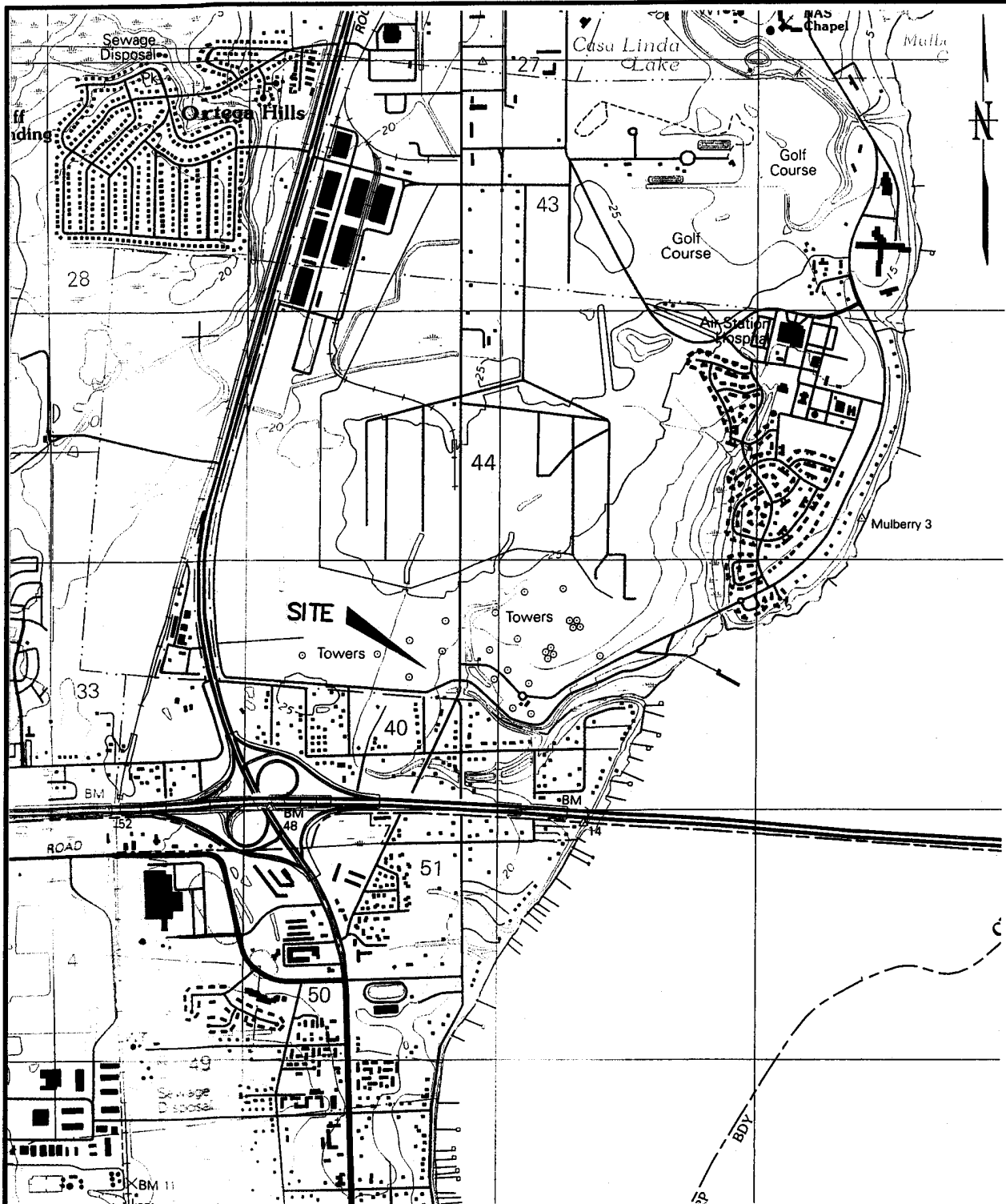
2.2.1 Geography, Demographics, and Land Use

PSC 51 is located within the SAF at NAS Jacksonville. The SAF is a large grassy field with no scrub brush or trees. The SAF is bordered to the north and west by forest, to the east by Allegheny Road beyond which are buildings, and to the south by the Patrol Road and fence marking the station's southern boundary. Beyond the fence is a wooded area that contains a creek and a residential area. There are no buildings present at the site; therefore, personnel are not routinely at the site for extended periods of time.

2.2.2 Physiography and Topography

NAS Jacksonville is located in the Coastal Plain physiographic province. The Coastal Plain is composed of marine sediments in the vicinity of the facility. The sediments were deposited in terraces related to prehistoric fluctuations in sea level. The terrace deposits are in the form of ridges that tend to parallel the current coastline. The topography of the terrace deposits is characterized by very low relief with gentle slopes to the east-southeast. Seven terraces are present in northeast Florida with NAS Jacksonville located within the Pamlico terrace [10-25 ft mean sea level (msl)].

The overall topography at PSC 51 is generally flat with a gentle slope to the southeast according to the topographic map for Orange Park (USGS, 1993). A topographical map is presented in Figure 2-4.



DRAWN BY DATE
LLK 6/13/00

CHECKED BY DATE

COST/SCHED-AREA

SCALE
NOT TO SCALE



1993 USGS TOPOGRAPHIC MAP
PSC 51
NAVAL AIR STATION JACKSONVILLE
JACKSONVILLE, FLORIDA

CONTRACT NO. 0253

APPROVED BY DATE

APPROVED BY DATE

DRAWING NO. FIGURE 2-4 REV. 0

SOURCE: Remedial Investigation and Feasibility Study Operable Unit 3, Harding Lawson Associates, May 1999

2.2.3 Climate

The climate in northeast Florida approaches semi-tropical as it lies near the northern limit of the trade winds (the prevailing easterly winds that moderate summer and winter temperatures). The annual mean temperature is 68 to 70 degrees Fahrenheit (°F) with an average temperature in the summer of 82 °F to 83 °F and a winter average 56 °F to 57 °F. Summer highs reach the middle to upper 90 °F, sometimes exceeding 100 °F. The winter lows can reach the upper teens, although temperatures seldom drop below freezing.

The region experiences an average of 53 to 54 inches of rainfall per year, most of which accumulates during frequent summer thunderstorms. Extended dry periods may occur throughout the year; however, they are most common in spring and fall. The relative humidity averages 87 percent and the average annual sunshine is 62 percent of the maximum.

Wind speed in northeast Florida averages eight miles per hour (mph) with winds predominantly from the northeast in the winter and from the southwest in the summer. Winds of hurricane force can be expected once in five years with significant deviations from the average. Tropical storm activity mostly occurs from August through October, although the six-month period from June 1 through November 30 is officially considered the Atlantic hurricane season.

2.2.4 Soil

Soil at NAS Jacksonville developed in marine terrace sediment deposits and is regionally classified by the United States Department of Agriculture (USDA), Soil Conservation Service as the Pelham-Mascotte-Sapelo soil series association. Soils in this association are characterized as nearly level, poorly drained sands to a depth of 20 inches bls, which are underlain by loamy sands (USDA, 1978).

2.2.5 Regional Geology

The geologic profile at NAS Jacksonville is comprised of unconsolidated surficial deposits of predominantly fine to very fine clastic sediments that range from clean medium- to fine-grained sands, to silty fine sands, to sandy and silty clay (Fairchild, 1972) overlying thick deposits of phosphatic sands and clays of the Hawthorn Group (Scott, 1988) and limestones and dolomites of the Floridan aquifer systems (Leve, 1966).

The Hawthorn Group is significant at NAS Jacksonville because it contains as much as 200 ft of low permeability, silty, sand-clay layers (Scott, 1988). This low permeability deposit acts as an aquiclude for

the underlying Floridan aquifer system. The Floridan aquifer system is the major source of potable water in the Jacksonville area and throughout much of northeastern and central Florida.

2.2.6 Site Specific Geology

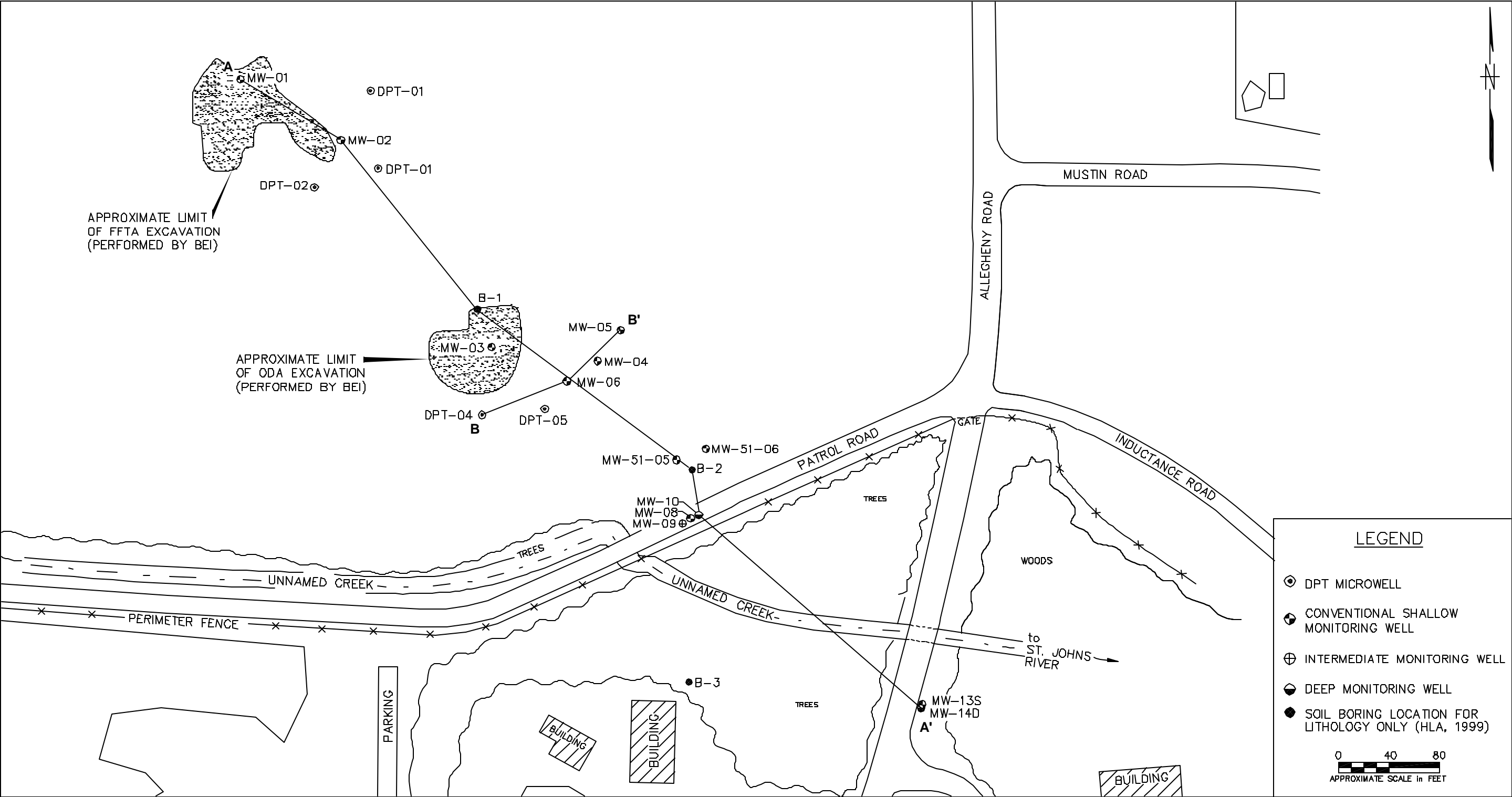
Site-specific geological information was obtained during the RI well installation activities at PSC 51. Lithological information collected during the RI was gathered using a hollow stem auger with a split-spoon and a hand auger (upper 6-ft). Depth-related geological information is limited to three deeper soil borings performed at the site. Shallow zone information was also collected at the direct push technology (DPT) well locations as the upper 6-ft were hand augured prior to well installation.


In general, the site geology is characterized by fine to medium grained unconsolidated sands encountered from the ground surface to depths varying from 2 to 4 ft bls. Below the sand, a sandy clay unit was encountered to an approximate depth of 6 ft bls followed by silty sand to a depth of approximately 35 to 40 ft bls. During DPT operations a weathered limestone with some clay was encountered at approximately 35 to 40 ft bls. A clay unit was encountered at 50 ft bls to a depth of greater than 70 ft bls. A Geologic Cross-Section Line Location Map and Geologic Cross Sections are provided in Figures 2-5 and 2-7

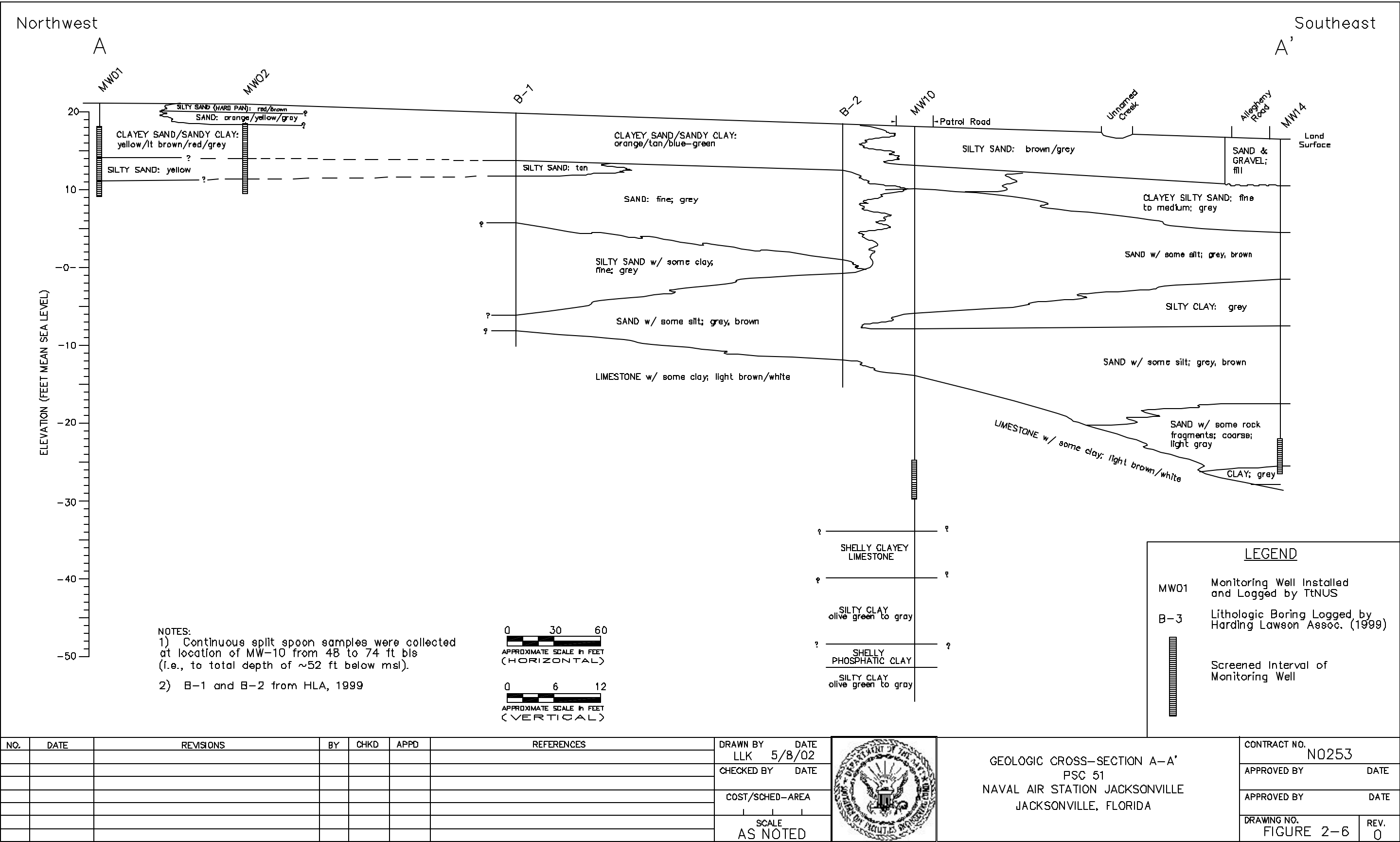
2.2.7 Regional Hydrology

2.2.7.1 Surface Water

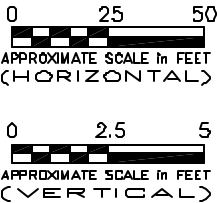
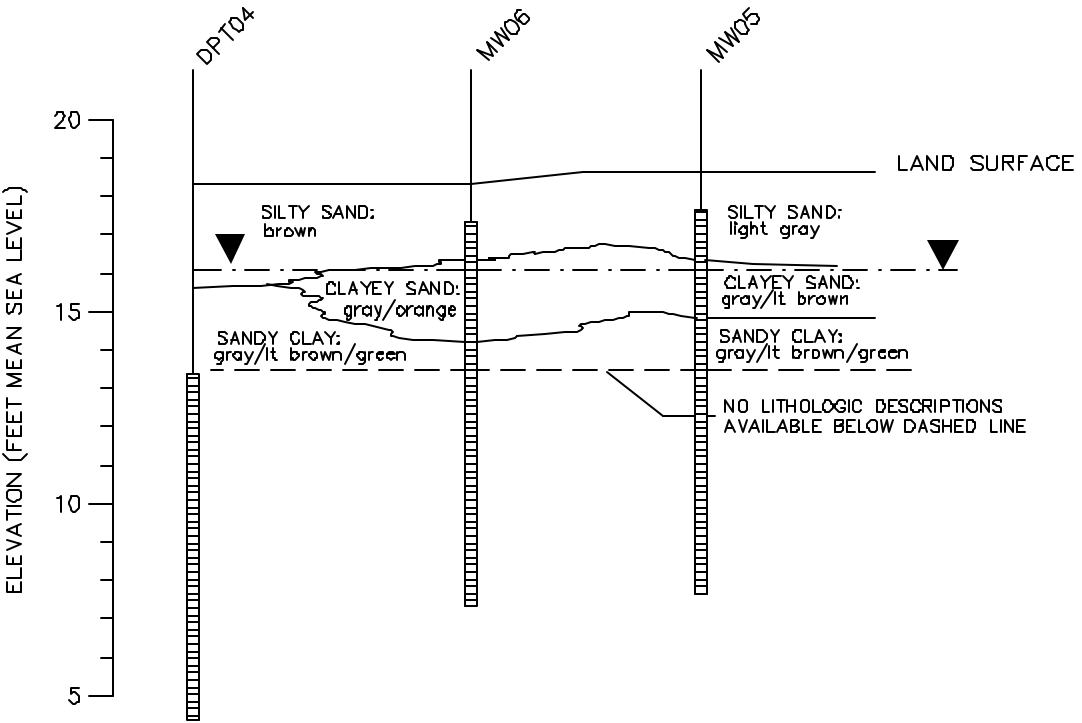
Two principal waterways are located near NAS Jacksonville including the St. Johns River and Ortega River. The St. Johns River forms the eastern boundary of NAS Jacksonville. The river is rated by the FDEP as a Class III water body, which is designated for fish and wildlife propagation and body contact recreational use. The river at this point is influenced by tidal action and can be considered part of the St. Johns River estuary (NAS Jacksonville, 1990). Based on salinity measurements taken during the Scoping Study Field Program (SSFP), which ranged from 7.0 to 8.8 parts per thousand (ppt) as reported in the OU 3 RI/FS, the water would be classified as marine. Salinity values greater than 2 ppt would support marine vegetation and aquatic life.



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		GEOLOGIC CROSS-SECTION LINE LOCATION MAP PSC 51 NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. N0253	
											APPROVED BY	DATE
											APPROVED BY	DATE
											DRAWING NO. FIGURE 2-5	REV. 0



Southwest
B
Northeast
B'




LEGEND

MW06 Conventional Monitoring Well
DPT04 Direct Push Microwell

Approximate Position of
Water Table



Screened Interval of
Monitoring Well

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY LLK	DATE 5/8/02		GEOLOGIC CROSS-SECTION B-B' PSC 51 NAVAL AIR STATION JACKSONVILLE JACKSONVILLE, FLORIDA		CONTRACT NO. N0253	
							CHECKED BY	DATE				APPROVED BY	DATE
							COST/SCHED-AREA					APPROVED BY	DATE
							SCALE AS NOTED					DRAWING NO. FIGURE 2-7	REV. 0

2.2.7.2 Groundwater

Three aquifer systems have been identified in the Jacksonville area including the surficial aquifer, intermediate aquifer consisting of permeable units within the Hawthorn formation, and the Floridan aquifer system.

The surficial deposits consist of sediments of Late Miocene to Recent age. The sediments are highly variable and include sands, shelly sands, coquina, silts, clay, and shell beds. While the surficial aquifer may be considered a single unit on a regional or base-wide scale, localized clay layers or discontinuous lenses may divide the aquifer into distinct permeable units (ABB-ES, 1995a). The contact between the surficial aquifer deposits and the underlying Hawthorn Group, containing the intermediate aquifer, is an unconformity generally identified by a coarse phosphatic sand and gravel bed (Leve, 1966). Average well yields in Jacksonville for the shallow groundwater aquifer were estimated by the City of Jacksonville Planning Department to be between 200 and 500 gallons per day (Toth, 1990). This groundwater is primarily used for lawn irrigations, domestic purposes, and the heat exchange unit in air conditioning and heating units.

The Hawthorn Group consists mainly of dark-gray and olive-green sandy to silty clay, clayey sand, clay and sandy limestone encountered at a depth of approximately 50 to 70 ft bls. Black phosphatic sand, granules, and pebbles are common throughout the Hawthorn Group (Fairchild, 1972). The combination of numerous thick clay layers within the Hawthorn Group serves as a confining layer that separates the surficial aquifer from the underlying Floridan aquifer system. The most common carbonate components of the Hawthorn Group are dolomite and dolosilt. Clay minerals associated with the Hawthorn Group sediments are smectite, illite, palygorskite, and kaolinite.

A marine carbonate sequence makes up the Floridan aquifer system beneath NAS Jacksonville. The formation of the Floridan aquifer are Eocene in age and consist of, in descending order, the Ocala Group, Avon Park Limestone, Lake City Limestone, and Oldsmar Limestone. The Floridan aquifer system is the principal source of fresh water in northeast Florida. The water bearing zones consists of soft, porous limestone and porous dolomite beds. The top of the Floridan aquifer in the vicinity of NAS Jacksonville occurs at a depth of about 400 ft bls. Published transmissivities of the Floridan aquifer in eastern Duval County range from approximately 85,000 to 160,000 gallons per day per foot (Leve, 1966). Groundwater in the Florida aquifer in the vicinity of NAS Jacksonville is moving eastward toward areas of heavy pumping (Fairchild, 1977). Florida aquifer wells in the vicinity of NAS Jacksonville are under sufficient artesian pressure to flow at the surface.

2.2.8 Site Hydrology

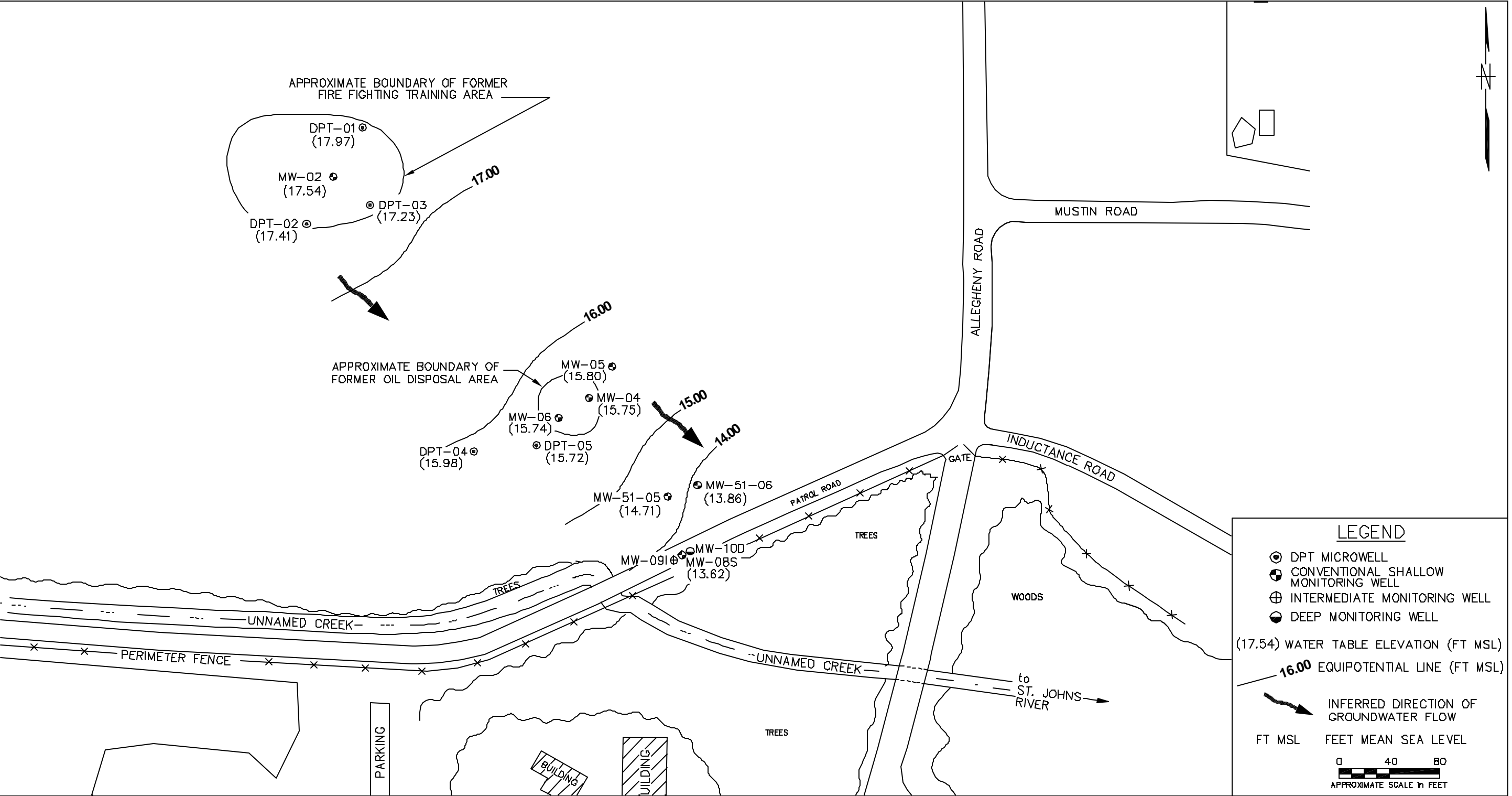
2.2.8.1 Surface Water


Surface water features in proximity to PSC 51 include the St. Johns River, located approximately 2,000 ft east of PSC 51, and an unnamed creek located immediately south of PSC 51. The unnamed creek serves as a discharge pathway for stormwater drainage from the southern portion of the base into the St. Johns River (TtNUS, 1999a). The creek has been incorporated into the sampling program at PSC 51 because shallow groundwater in the area intersects the creek and may serve as a source of surface water contamination (HLA, 1999a).

2.2.8.2 Groundwater

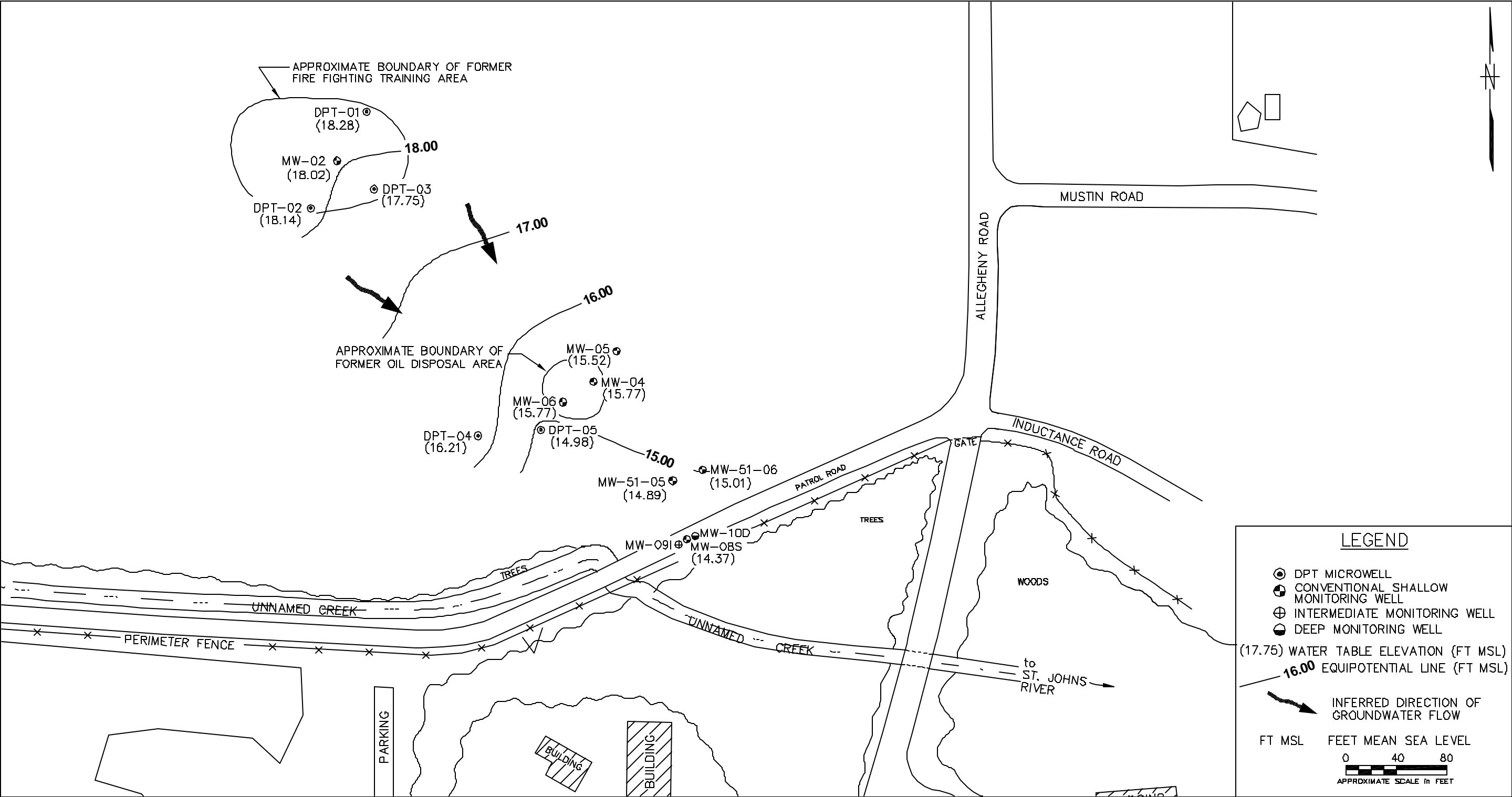
The shallow aquifer at PSC 51 is comprised of a layer of silty sands from approximately 6 ft bls to approximately 50 ft bls. Discontinuous clay lenses are also interspersed throughout the shallow aquifer. The shallow aquifer extends to approximately 50 ft bls where the Hawthorn formation is encountered. The shallow groundwater zone is unconfined in nature and is typically encountered at a depth of approximately 3 to 4 ft bls. Water table contours as shown on Figures 2-8 and 2-9 indicate that groundwater flow in the shallow aquifer is to the southeast toward the unnamed creek.

The October 2, 2001 water table elevation data from Table 4-1 was provided to the USGS for groundwater flow analysis. Mr. Hal Davis of the USGS provided information on the groundwater flow at the site, and provided two figures indicating groundwater flow in the shallow and deep portions of the surficial aquifer. The two figures are included as Appendix A. As indicated by the USGS, the water levels for the shallow wells are shown in Figure 1 of Appendix A. The water table slopes to the unnamed creek from PSC 51, and from the housing subdivision to the south. The water level contours for the deeper part of the surficial aquifer are shown in Figure 2 in Appendix A. Similar to the water table, the deeper water levels slope toward the creek from all directions. The groundwater flow gradient toward the creek from both the station and the community indicate that the creek is draining the surficial aquifer to the St. John's River.



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		GROUNDWATER ELEVATION CONTOUR MAP DECEMBER 13, 1999 PSC 51 NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. N0253		
							CW	9/19/00			APPROVED BY	DATE	
								CHECKED BY			DATE	APPROVED BY	DATE
								COST/SCHED-AREA				DRAWING NO.	REV.
								SCALE AS NOTED				FIGURE 2-8	0

S:\NAVY\SITES\CTO 100\CAD\0253GF1001



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		GROUNDWATER ELEVATION CONTOUR MAP		CONTRACT NO. N0253	
							LLK	4/24/02		OCTOBER 2, 2001		APPROVED BY	DATE
										PSC 51		APPROVED BY	DATE
										NAS JACKSONVILLE		DRAWING NO. FIGURE 2-9	REV. 0
										JACKSONVILLE, FLORIDA			

The groundwater flow velocity was calculated for the shallow aquifer at PSC 51 using the formula $v = k (h_1 - h_2) / L / n$ where:

v = horizontal component of groundwater

k = hydraulic conductivity

h_1 and h_2 = groundwater elevation at arbitrary points 1 and 2, respectively

L = the horizontal distance between arbitrary points 1 and 2

n = porosity

and

$(h_1 - h_2) / L$ = the average hydraulic gradient (0.009 ft per ft) as calculated using measurements from Figure 2-8, Groundwater Elevation Contour Map.

Hydraulic conductivity (k) was obtained from information provided by the USGS from OU 1 (Davis, 1996) at NAS Jacksonville, which is located approximately 4,000 ft north-northeast of PSC 51. The hydraulic conductivity in the surficial aquifer was determined by the USGS using the results of a multiple well aquifer test, as 5 ft per day (ft/d).

A porosity value of 0.3 (Freeze/Cherry, 1979 and Hal Davis of USGS) for sandy clay and silty sand was assumed.

The December 1999 groundwater elevation values from monitoring wells MW-02 and MW-08S, and the horizontal distance between the two wells were used to calculate the hydraulic gradient.

Based on the above values, the velocity of shallow groundwater at PSC 51 is 0.15 ft/d or 54.75 ft/y toward the southeast. This calculated value is influenced by the more severe gradient near the creek.

The vertical gradient of groundwater at a site can be inferred from the difference in the groundwater elevation between adjacent wells with screen intervals set at different depths in the aquifer. Three such monitoring well nests are located at PSC 51. These monitoring well nests are MW-09I and MW-10D, MW-11S and MW-12D, and MW-13S and MW-14D as shown on Figure 2-9. At MW-09I and MW-10D there was a 0.06 ft downward gradient between the intermediate and deep well. At the well nest MW-11S and MW-12D there was a 0.78 ft downward gradient between the shallow and deep well. At the well nest MW-13S and MW-14D there is a 1.34 ft upward gradient between the shallow and deep well located near the creek indicating that water in the deeper part of the surficial aquifer is discharging to the creek.

3.0 PREVIOUS SITE INVESTIGATIONS AND REMEDIAL ACTIONS

The following sections describe the previous investigations and remedial actions performed by BEI between September 1997 and October 1998 and HLA between March and October 1997. The investigation and removal action information are presented in relative chronological order from the earlier activities to the most recent. In addition, PSC 51 is discussed as a singular site although the previous investigations have addressed the two areas, ODA and FFTA, that comprise PSC 51.

3.1 RADIOLOGICAL INVESTIGATION MEMORANDUMS (BEI)

A BEI interoffice memorandum to file, with a subject line of "Radiological Survey, PSC 51" dated September 25, 1997 reported that on September 25, 1997 T. Roundtree and Gene Jaska of BEI performed a cursory radiological survey of two areas of distressed vegetation at PSC 51. The results of the survey indicated the potential for "radiological contamination over the clean up criteria of 5 PicoCuries per gram (pCi/g)". A subsequent detailed investigation was performed on September 24, 1997 by BEI for two areas that comprise PSC 51: Area 1 (ODA) and Area 2 (FFTA).

During the subsequent investigation, background for the area was established by BEI as 7,378 curies per meter (cpm). The investigators used an "NAS Jacksonville standard" of background plus 4,750 cpm (12,128 cpm for PSC 51) to determine areas of suspicion. Two sampling points were used in each area. Readings from the ODA varied with depth and the probe used (Ludlum 2221 with a 44-10 probe and a 43-5 probe) from 0 cpm to 70,797 cpm. At the FFTA, readings varied from 0 cpm to 109,835 cpm. In addition, during this investigation, an alpha meter was used at the surface to verify the presence of surface contamination. No detections were reported, however, BEI reported their results may indicate that the radioisotope was not an alpha emitter.

A second BEI interoffice memorandum, this one to V. H. Bauer, with a subject line of "NAS-JAX PSC 51 Radiological Characterization" dated April 21, 1998 was reviewed. This memo reported on the earlier radiological survey and the memo summarizing the effort dated September 25, 1997 (see above). It also reported on additional investigation activities performed by BEI to "further characterize this area and determine the areal extent and depth of the elevated activity to support remediation work planning". The effort included obtaining additional surface readings, borehole measurements and material samples for isotope identification and concentration. The investigation determined that a maximum volume of 400 cubic yards (yd³) would require remediation.

3.2 SAMPLING EVENT REPORT (HARDING LAWSON ASSOCIATES)

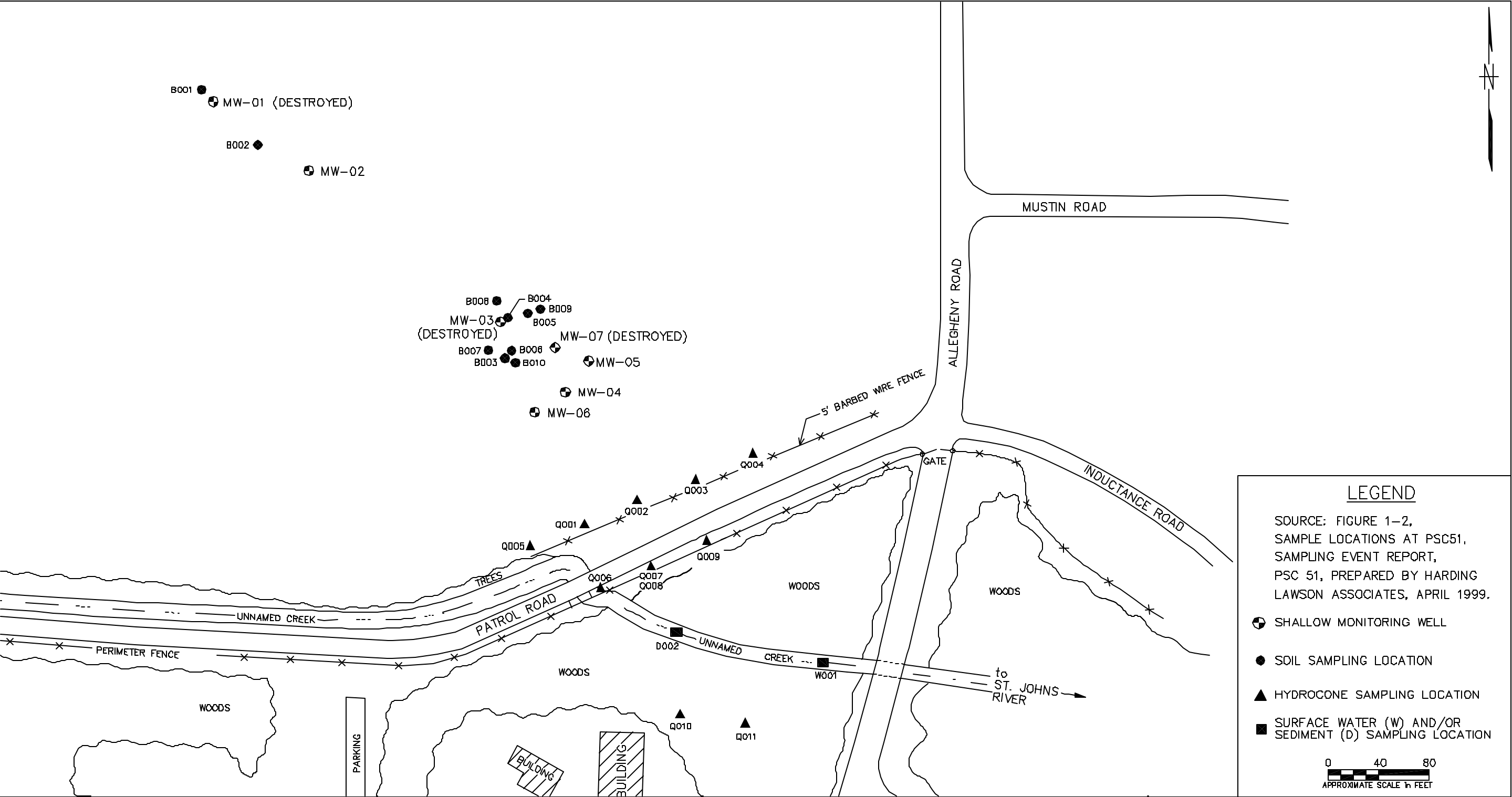
HLA's Sampling Event Report (SER) (HLA, 1999a) documents field investigation activities conducted from March to October 1997. The investigation, conducted according to the Site Screening Workplan (SSW) prepared by ABB-ES in 1997 (ABB-ES, 1997), was intended to assess potential contamination from past activities at the FFTA and ODA. HLA installed seven groundwater monitoring wells (MW-01 through MW-07) and collected groundwater, surface soil, subsurface soil, surface water and sediment samples for laboratory analyses during the course of the investigation. HLA sampling and monitoring well locations for the FFTA and ODA are presented in Figure 3-1.

3.2.1 Surface Soil

Surface soil samples collected from the FFTA and ODA were analyzed for TCL VOCs, TCL SVOCs, pesticides, PCBs, and TAL inorganics. Summary results are reported in this document.

Four samples were collected from the FFTA and analyzed as reported above. HLA compared the analytical results to the residential criteria in the FDEP Soil Cleanup Goals (SCGs) for Florida (September 1995). Five inorganics (arsenic, beryllium, chromium, lead, and manganese) exceeded the residential levels for FDEP's SCGs. Arsenic was detected in all four samples at concentrations ranging from 1.1 milligrams per kilogram (mg/kg) to 2.6 mg/kg. The remainder of inorganic constituents were detected in samples 51B00101 and 51B00201. A summary of detections in surface soil samples collected from the FFTA exceeding residential SCGs is presented in Table 3-1.

Sixteen surface soil samples were collected from the ODA at depths of 0 to 1 ft bls and 1 to 2 ft bls. One surface soil sample (51B00402) had VOC detections exceeding FDEP SCGs including carbon tetrachloride [1800 micrograms per kilogram ($\mu\text{g/kg}$)], chloroform (2,400 $\mu\text{g/kg}$), benzo(a)anthracene (1,800 $\mu\text{g/kg}$), benzo(a)pyrene (1,100 $\mu\text{g/kg}$), benzo(f)fluoranthene (1,400 $\mu\text{g/kg}$), and alpha-BHC (200 $\mu\text{g/kg}$). Arsenic, beryllium and lead were detected in excess of residential SCGs. Carbon tetrachloride, chloroform, and benzo(a)pyrene were compared to FDEP SCGs and Region 3 Risk-based Concentrations (RBCs). Both carbon tetrachloride and chloroform exceeded FDEP SCGs; however, both were below Region 3 RBCs. Benzo(a)pyrene exceeded both FDEP SCGs and Region 3 RBCs. A summary of detections in surface soil samples collected from the ODA exceeding regulatory criteria in at least one sample is presented in Table 3-2.



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		CONTRACT NO.
							LLK	5/9/02		N0253
							CHECKED BY	DATE		APPROVED BY DATE
							COST/SCHED-AREA			APPROVED BY DATE
							SCALE			DRAWING NO. REV.
							AS NOTED			FIGURE 3-1 0

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	FDEP SCGs Residential mg/kg	Sample ID, Date, and Depth							
		51B00101 4/16/1997 0-1 ft		51B00102 4/16/1997 1-2 ft		51B00201 4/16/1997 0-1ft		51B00202 4/16/1997 1-2 ft	
<u>Inorganics (mg/kg)</u>									
Arsenic	0.8	1.2	J	2.6		1.6	J	1.1	J
Beryllium	0.2	0.26		0.14	J	0.4	J	0.13	J
Chromium	290	365		12.2		573		17	
Lead	500	727	J	8.4	J	542	J	9.2	J
Manganese	370	459		2.1	J	526	J	3.9	J
Notes:									
The information presented here was extracted from the Sampling Event Report (HLA, 1999a).									
J - Estimated value									

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	FDEP SCGs Residential ¹	Sample ID, Date, and Depth															
		51B00301		51B00302		51B00401		51B00402		51B00501		51B00502		51B00601		51B00602	
		4/16/1997	4/16/1997	4/16/1997	4/16/1997	10/28/1997	10/28/1997	10/28/1997	10/28/1997	10/28/1997	10/28/1997	10/28/1997	10/28/1997	10/28/1997	10/28/1997	10/28/1997	
		0-1 ft	1-2 ft	0-1 ft	1-2 ft	0-1 ft	1-2 ft	0-1 ft	1-2 ft	0-1 ft	1-2 ft	0-1 ft	1-2 ft	0-1 ft	1-2 ft	0-1 ft	1-2 ft
<u>Volatile Organic Compounds (µg/kg)</u>																	
Carbon tetrachloride	600	11	U	12	U	7	J	1800		12	U	30	U	12	U	12	U
Chloroform	600	11	U	12	U	26		2400	J	1	J	4	J	18		10	J
<u>Semivolatile Organic Compounds (µg/kg)</u>																	
Benzo(a)anthracene	1400	380	U	410	U	410	U	1800	J	NA		NA		NA		NA	
Benzo(a)pyrene	100	380	U	410	U	410	U	1100	J	NA		NA		NA		NA	
Benzo(a)fluoranthene	1400	380	U	410	U	410	U	1400	J	NA		NA		NA		NA	
<u>Pesticides/PCBs (µg/kg)</u>																	
alpha-BHC	200	1.9	U	2.1	U	6.3	U	200		NA		NA		NA		NA	
<u>Inorganics (µg/kg)</u>																	
Arsenic	0.8	1.1	J	4.2		0.69	U	0.68	U	NA		NA		NA		NA	
Beryllium	0.2	0.12	J	0.4	J	0.1	U	0.06	U	NA		NA		NA		NA	
Chromium	290	6.2		11.1		6.4		86.6		NA		NA		NA		NA	
Lead	500	166	J	13	J	51.4		1030		NA		NA		NA		NA	
Manganese	370	2.8	J	2.8	J	3.6	J	6.1		NA		NA		NA		NA	
See notes at end of table																	

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	FDEP SCGs Residential ¹	Sample ID, Date, and Depth															
		51B00701 10/28/1997 0-1 ft		51B00702 10/28/1997 1-2 ft		51B00801 10/28/1997 0-1 ft		51B00802 10/28/1997 1-2 ft		51B00901 10/28/1997 0-1 ft		51B00902 10/28/1997 1-2 ft		51B01001 10/28/1997 0-1ft		51B01002 10/28/1997 1-2 ft	
<u>Volatile Organic Compounds (µg/kg)</u>																	
Carbon tetrachloride	600	12	U	12	U	30	U	30	U	12	U	12	U	12	U	12	U
Chloroform	600	12	U	12	U	15	J	28	J	12	U	12	U	12	U	12	U
<u>Semivolatile Organic Compounds (µg/kg)</u>																	
Benzo(a)anthracene	1400	NA		NA		NA		NA		NA		NA		NA		NA	
Benzo(a)pyrene	100	NA		NA		NA		NA		NA		NA		NA		NA	
Benzo(a)fluoranthene	1400	NA		NA		NA		NA		NA		NA		NA		NA	
<u>Pesticides/PCBs (µg/kg)</u>																	
alpha-BHC	200	NA		NA		NA		NA		NA		NA		NA		NA	
<u>Inorganics (µg/kg)</u>																	
Arsenic	0.8	NA		NA		NA		NA		NA		NA		NA		NA	
Beryllium	0.2	NA		NA		NA		NA		NA		NA		NA		NA	
Chromium	290	NA		NA		NA		NA		NA		NA		NA		NA	
Lead	500	NA		NA		NA		NA		NA		NA		NA		NA	
Manganese	370	NA		NA		NA		NA		NA		NA		NA		NA	
Notes:																	
¹ Expressed in µg/kg with the exception of the inorganics, which are expressed in mg/kg.																	
The information presented here was extracted from the Sampling Event Report (HLA, 1999a).																	
BHC - Benzene Hexachloride																	
J - Estimated value																	
U - Not detected																	
NA - Well not analyzed for this analyte																	

3.2.2 Subsurface Soil

Subsurface soil samples from the FFTA and ODA were analyzed for TCL VOCs, TCL SVOCs, pesticides, PCBs, and TAL inorganics. The analytical results were compared to the leaching criteria in the FDEP SCGs for Florida (September 1995). The analytical results from the four soil samples collected from the FFTA did not exceed the leaching criteria SCGs.

Four subsurface soil samples were collected from the ODA at depths of 2 to 3 ft bls and 3 to 4 ft bls. Naphthalene, detected above FDEP leaching criteria SCG in samples 51B00304 (290 µg/kg) and 51B00403 (1,100 µg/kg), was one of only two constituents with an SCG. There were no listed SCGs for carbon tetrachloride (detected at 89,000 µg/kg) and chloroform (detected at 14,000 µg/kg) in sample 51B00403.

3.2.3 Groundwater

At the FFTA, two DPT monitoring wells, MW-01 and MW-02, were installed to a depth of approximately 12 ft bls. Well MW-01 was installed near the center of the FFTA and MW-02 was installed downgradient (southeast) of MW-01 near the perimeter of the FFTA. Two monitoring wells, MW-03 and MW-04, were installed at the ODA to a depth of approximately 12 ft bls. Well MW-03 was installed near the center of the ODA and well MW-04 installed near the perimeter of the ODA, downgradient of well MW-03. Groundwater samples were collected from these wells and analyzed for TCL VOCs, TCL SVOCs, TCL pesticides & PCBs, and TAL inorganics. HLA compared the analytical results to FDEP Groundwater Guidance Concentrations (GGCs), USEPA Maximum Contaminant Levels (MCLs), and basewide background concentrations established for NAS Jacksonville collected in support of the OU 1 RI/FS.

The analytical results of the groundwater samples collected from the FFTA wells reported two inorganic constituents, iron and manganese, above FDEP GGCs and USEPA MCLs. Iron was detected in well MW-01 and MW-02 at concentrations of 687 micrograms per liter (µg/L) and 1,310 µg/L, respectively, exceeding the FDEP GGC and USEPA MCL of 50 µg/L. Manganese was detected in well MW-02 at 81.5 µg/L, exceeding the FDEP GGC and USEPA MCL of 300 µg/L. Neither constituent exceeded NAS Jacksonville background values. Table 3-3 presents a summary of the groundwater detections from the monitoring wells associated with the FFTA exceeding regulatory criteria.

Groundwater samples from the monitoring wells installed near the ODA were collected on April 21, 1997 from MW-04. A sample was not collected from well MW-03 due to the presence of "floating petroleum

Table 3-3
Groundwater Detections Exceeding Regulatory Criteria
Fire Fighter Training Area

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	Regulatory Criteria		NASJAX Background Concentrations ¹ µg/L	Well ID and Sample Date	
	FDEP GGCs µg/L	EPA MCLs µg/L		MW-01 4/8/1997	MW-02 4/8/1997
<u>Inorganics (µg/L)</u>					
Iron	300	300	68292	687	1310
Manganese	50	50	204	45.4	81.5
Notes: Bolded values indicate the concentration exceeds regulatory criteria. ¹ - Background concentrations adopted from a basewide background sampling program performed by ABB -ES as documented in the OU 1 RI/FS, March 1, 1996. The information presented here was extracted from the Sampling Event Report (HLA, 1999a).					

product” (HLA, 1999a). Constituents exceeding FDEP GGCs and USEPA MCLs included 1,2-dichloroethene (DCE) (81 µg/L), benzene (130 µg/L), naphthalene (26 µg/L), aluminum (548 µg/L), iron (7,350 µg/L), and manganese (72 µg/L).

Three additional wells (MW-05, MW-06, and MW-07) were installed near the southern edge perimeter of the ODA and sampled on August 6, 1997. The samples were analyzed for TCL VOCs only. Constituents exceeding FDEP GGCs and USEPA MCLs included 1,2-DCE in well MW-06 (120 µg/L), benzene in wells MW-05 (34 µg/L), MW-06 (240 µg/L), and MW-07 (4 µg/L), TCE in wells MW-05 (23 µg/L), MW-06 (17 µg/L), and MW-07 (14 µg/L), and vinyl chloride in well MW-06 (10 µg/L). The summary of HLA’s constituent detection in groundwater from monitoring wells associated with the ODA exceeding GGCs is presented in Table 3-4.

The analytical results from the August 1997 sampling event facilitated additional groundwater sampling to determine the aerial extent of contaminant migration at the ODA. Hydrocone sampling with a DPT rig was used to collect 29 groundwater samples at two to three depth intervals at 11 locations. The samples were collected between September 3, 1997 and October 1, 1997 and analyzed for TCL VOCs. Three constituents were detected above FDEP GGCs and/or USEPA MCLs and are included as follows: benzene exceeded GGCs in 12 samples (2 to 48 µg/L), TCE was detected in three samples (3.1 to 11 µg/L), and vinyl chloride was detected in nine samples (1.8 to 18 µg/L). The results of the hydrocone sampling are summarized on Table 3-5, and the location of the hydrocone points are depicted on Figure 3-1.

3.2.4 Surface Water

The potential for impact to surface water in the unnamed creek downgradient of PSC 51 was assessed. The creek is believed to be the primary receptor of groundwater from PSC 51. In order to determine the impact from groundwater contamination, one surface water and two sediment samples were collected and analyzed for TCL VOCs. The results for the three samples collected reported no analytes detected.

3.2.5 Focused Risk Evaluation (FRE)

HLA completed a FRE as part of the SER (HLA, 1999a), where maximum values for benzene, TCE, and vinyl chloride were compared with FDEP GGCs, USEPA MCLs, and Region 3 Tap Water Screening Values. HLA concluded that groundwater is a potentially significant exposure pathway at PSC 51 and identified the residences located south of the site due to their use of private drinking water wells.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	Regulatory Criteria		NASJAX Background Concentrations ¹ µg/L	Well ID and Sample Date				
	FDEP GGCs µg/L	EPA MCLs µg/L		MW-03	MW-04	MW-05	MW-06	MW-07
<u>Volatile Organic Compounds (mg/L)</u>								
1,2-DCE	70	70	--	NS	81	37	120	2 J
Benzene	1	5	--	NS	130	34	240	4 J
TCE	3	5	--	NS	1 J	23	17	14
Vinyl Chloride	1	2	--	NS	10 U	10 U	10 J	10 U
<u>Semivolatile Organic Compounds (mg/L)</u>								
Naphthalene	6.8	--	--	NS	26	NA	NA	NA
<u>Inorganics (mg/L)</u>								
Aluminum	200	200	147,659	NS	548	NA	NA	NA
Iron	300	300	68,292	NS	7350	NA	NA	NA
Manganese	50	50	204	NS	72	NA	NA	NA
Notes:								
NS - Not sampled due to the presence of floating free product								
U - Not detected								
J - Estimated value								
NA - Sample not analyzed for this constituent								
-- no value listed for this constituent.								
Bolded values indicate concentration exceeds the regulatory criteria.								
¹ - Background concentrations adopted from a basewide background sampling program performed by ABB -ES as documented in the OU 1 RI/FS, March 1, 1996.								

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	Regulatory Criteria		Location ID, Depth and Sample Date									
	FDEP GGCs µg/L	EPA MCLs µg/L	Q00402	Q00403	Q00501	Q00502	Q00503	Q00601	Q00602	Q00701	Q00702	Q00801
			15.5-17.5'	27.5-28.5'	6-10'	15.5-17.5	27.5-28.5'	6-10'	20-24'	6-10'	20-24'	20-24'
			9/4/1997	9/5/1997	9/5/1997	9/5/1997	9/5/1997	9/9/1997	9/9/1997	9/9/1997	9/9/1997	9/12/1997
<u>Volatile Organic Compounds (mg/L)</u>												
1,1-DCE	70	70	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U
Benzene	1	5	1U	1U	13	1U	1U	2	1U	5	25	28
Carbon Disulfide	700	NL	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ
TCE	3	5	1U	1U	1U	1U	1U	1U	1U	2	1U	1U
Ethylbenzene	30	700	1U	1U	1U	1U	1U	1U	1U	1U	3	4
o-Xylene	20	10000	1U	1U	1U	1U	1U	1U	1U	1U	5	5
m/p-Xylene	20	10000	2U	2U	2U	2U	2U	2U	2U	2U	9	10
Vinyl Chloride	1	2	1U	1U	5	1U	1U	4	1U	5	4	4
See notes at end of table.												

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	Regulatory Criteria		Location ID, Depth and Sample Date								
	FDEP GGCs µg/L	EPA MCLs µg/L	Q00901	Q00902	Q00903	Q01001	Q01002	Q01003	Q01101	Q01102	Q01103
			6-10'	20-24'	28-32'	8-12'	17-21'	28-32'	8-12'	17-21'	28-32'
			9/29/1997	9/29/1997	9/29/1997	9/30/1997	9/30/1997	9/30/1997	10/1/1997	10/1/1997	10/1/1997
<u>Volatile Organic Compounds (mg/L)</u>											
1,1-DCE	70	70	5U	5U	5U	5U	5U	5U	5U	5U	5U
Benzene	1	5	9.4	5U	5U	5U	5U	5U	5U	5U	5U
Carbon Disulfide	700	NL	5U	5U	5U	5U	5U	5U	9.9	5U	5U
TCE	3	5	11	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	30	700	5U	5U	5U	5U	5U	5U	5U	5U	5U
o-Xylene	20	10000	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ
m/p-Xylene	20	10000	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ
Vinyl Chloride	1	2	10U	10U	10U	10U	10U	10U	10U	10U	10U
Notes: U - Not detected J - Estimated value NA - Sample not analyzed for this constituent NL - no value listed for this constituent. NQ - parameter not quantified or reported on Form 1's. ¹ - Background concentrations adopted from a basewide background sampling program performed by ABB-ES as documented in the OU 1 RI/FS. March 1, 1996.											

In the FRE, maximum analytical values for carbon tetrachloride, chloroform, and benzo(a)pyrene were compared to FDEP residential and industrial SCGs and USEPA Region 3 RBCs. Although no conclusions were drawn from the surface soil data, HLA assessed that high levels of carbon tetrachloride and chloroform detected in the subsurface soil provided a potential source for contamination of groundwater and potential direct exposure to maintenance or construction workers performing excavations at the SAF.

Based on the results of the FRE, HLA reported that further investigation of the groundwater to off-site residents exposure route was warranted.

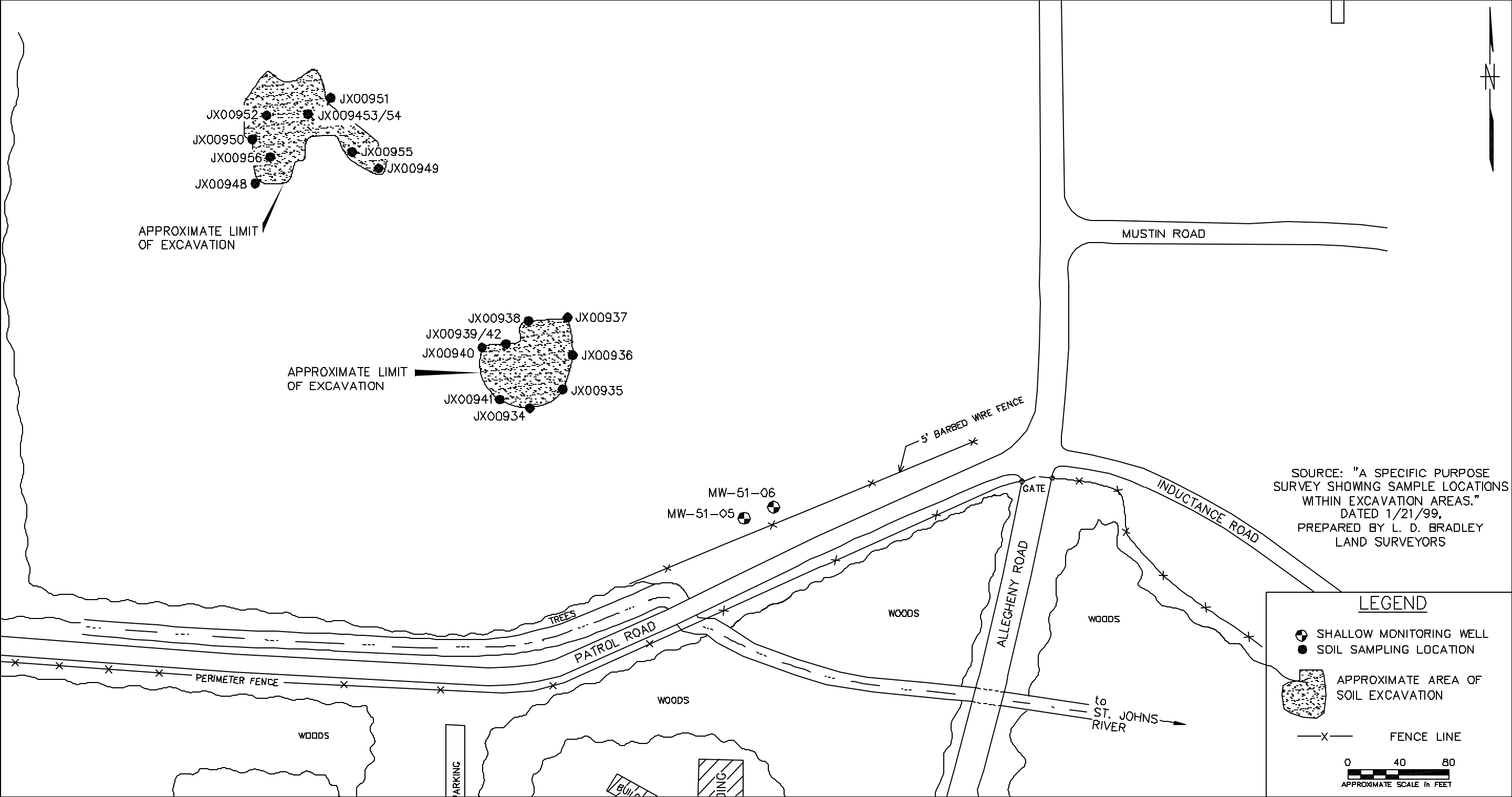
3.3 REMOVAL ACTION AT PSC 51 (BEI)



The "Completion Report for the Removal Action at PSC 51 South Antenna Area" dated January 1999 and prepared by BEI documents field investigation/removal activities conducted from March to October 1998 at PSC 51. Field activities included identification and removal of radiologically contaminated soil, removal of lead contaminated soil, installation and sampling of two groundwater monitoring wells (MW-51-05 and MW-51-06), radiological and lead confirmatory sampling, chemical sampling for potential use in the remedial investigation, and the backfilling of the excavations with clean soil. As indicated in the completion report, the backfill source was identified prior to commencement of earthwork activities and qualified under applicable provisions of Standard Specification 22567-001-006, *Technical Specification for Uncontaminated Earthwork*. BEI sampling and monitoring well locations for the FFTA and ODA are presented in Figure 3-2.

Previous radiological screening activities (reported above) revealed levels of radiation ranging from 0 to 109,835 cpm within the FFTA and 0 to 70,797 cpm within the ODA. The areal extent of contamination in each area was determined to correspond to the barren (unvegetated) surface areas and the vertical extent of contamination was determined to extend approximately 30 inches bls at the ODA and approximately 24 inches bls at the FFTA. The highest activity was within the first 6 to 12 inches of the surface.

IMs were implemented to remove the radiologically contaminated soil in each area. Approximately 1,000 yd³ of radiologically contaminated soils were transported to the OU 1 landfill from the two excavations. During the excavation activities, the ODA was identified as having a layer of black, oily material mixed with soil in a large concave depression. Further excavation revealed a 20-gallon drum containing black sludge in the bottom of the depression. The radiologically contaminated soils and the drum discovered in the ODA were transported to the OU 1 landfill for disposal. Removal of radiological contamination was confirmed as the excavation proceeded vertically using a gamma scintillation meter.

S:\NAVY\STES\CTO 111\CAD\02530M05



NO.		DATE	REVISIONS		BY	CHKD	APPD	REFERENCES		DRAWN BY		DATE		BECHTEL SAMPLING LOCATIONS AND AREAS OF SOIL EXCAVATION PSC 51 NAS JACKSONVILLE JACKSONVILLE, FLORIDA		CONTRACT NO.		0253
										LLK		5/8/02				APPROVED BY		DATE
										CHECKED BY		DATE				APPROVED BY		DATE
										COST/SCHED—AREA						APPROVED BY		DATE
										SCALE						DRAWING NO.		REV.
										AS NOTED						FIGURE 3-2		0

The final FFTA radiological excavation area extended to approximately 3 ft bls and the ODA excavation area extended 5 ft bls. Upon completion, 27 confirmatory soil samples were collected for laboratory analysis. BEI did not draw any conclusion or make recommendations based on the analytical data. A review of the results by TtNUS, indicated that one soil sample (JX00966), detected at 5.2 pCi/g, exceeded the aforementioned USEPA radiological criteria.

During the excavation, samples were also collected for Toxicity Characteristic Leaching Procedure (TCLP) VOC, TCLP SVOC, and TCLP metals analyses to determine the presence of chemically and radiologically mixed wastes. A small area of lead-contaminated (hazardous) soil was discovered within the ODA. The lead-contaminated soil, was not radiologically contaminated. Approximately 20 yd³ of lead-contaminated soils were loaded into a container for off-site disposal by the Public Works Center (PWC). The lead excavation in the ODA area extended to approximately 9 ft in depth and the lead samples were collected from 7 ft bls. Post-excavation sampling for TCLP lead was performed at five locations within the ODA excavation. These results indicated that the TCLP lead concentrations were below method detection limits.

Groundwater intrusion into the ODA excavation prompted sampling of the ponded water within the excavation to determine radiological contamination. Since no groundwater accumulated in the FFTA excavation, a shallow boring was installed in the excavation. BEI collected "surface water samples" from both locations to verify the presence or absence of radiological contamination. BEI made no comparison of the values to the USEPA radiological criteria. However, Radium-226 and Thorium-230 were detected in the sample from the FFTA excavation, each at a concentration of 46.9 PicoCuries per liter (pCi/L). Uranium-238 was estimated at a concentration of 164 pCi/L (between detection limits and reporting limits) in the sample collected from the ODA.

In June through July of 1998, nine post-excavation chemical soil samples were collected at the surface at the limits of each excavation and/or on the surface within the the excavation. The nine samples (JX00948 through JX00956) from the FFTA (identified as PSC 51B by BEI) were analyzed for VOCs and SVOCs. In the BEI Completion Report, BEI only provided the data in an appendix and did not perform any form of data analysis. Therefore, for the purposes of this RI, TtNUS has compared the laboratory results to residential, industrial and leaching FDEP SCTLs, and USEPA RBCs (both residential and industrial). None of the constituents analyzed were detected in excess of these criteria. A summary of constituents detected in the samples from the FFTA is provided in Table 3-6.

The nine chemical samples from the ODA (JX00934 through JX00942) were analyzed for VOCs, SVOCs and Resource Conservation and Recovery Act (RCRA) metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). Five VOCs were detected in excess of the current FDEP

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	Regulatory Criteria			Sample ID and Depth				
	FDEP SCTLs Residential/Industrial/ Leaching mg/kg	EPA RBCs Residential/Industrial mg/kg	EPA PRGs Residential/Industrial mg/kg	JX00948	JX00949	JX00950	JX00951	JX00952
				7/2/1998	7/2/1998	7/2/1998	7/2/1998	7/2/1998
<u>Volatile Organic Compounds (mg/kg)</u>								
1,2,4-Trimethylbenzene	13/88/0.3	3,900/100,000	5.7/5.7	0.001 I	0.001 U	0.002 I	0.18 U	0.0064
1,3,5-Trimethylbenzene	11/74/0.3	3,900/100,000	21/70	0.001U	0.001 U	0.001 U	0.18 U	0.0014
Benzene	1.1/1.6/0.007	22/200	0.67/1.5	0.001U	0.001 U	0.001 U	0.18 U	0.0022
Ethylbenzene	1,100/8,400/0.6	7,800/20,000	230/230	0.001U	0.001 U	0.001 U	0.18 U	0.0082
Naphthalene	40/270/1.7	1,600/41,000	56/190	0.036	0.0057	0.038	0.18 U	0.075
Toluene	380/2600/0.5	16,000/410,000	520/520	0.001 U	0.0016 I	0.0018 I	0.18 U	0.001 U
Xylenes, total *	5.9/22/0.2	160,000/4,100,000	210/210	0.003 U	0.003 U	0.003 U	0.54 U	0.0063
See notes at end of table.								

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	Regulatory Criteria			Sample ID and Depth			
	FDEP SCTLs Residential/Industrial/ Leaching mg/kg	EPA RBCs Residential/Industrial mg/kg	EPA PRGs Residential/Industrial mg/kg	JX00953	JX00954	JX00955	JX00956
				7/2/1998	7/2/1998	7/2/1998	7/2/1998
<u>Volatile Organic Compounds (mg/kg)</u>							
1,2,4-Trimethylbenzene	13/88/0.3	3,900/100,000	5.7/5.7	0.0048	0.001 U	0.001 U	0.001 U
1,3,5-Trimethylbenzene	11/74/0.3	3,900/100,000	21/70	0.001 U	0.001 U	0.001 U	0.001 U
Benzene	1.1/1.6/0.007	22/200	0.67/1.5	0.002	N/A	N/A	0.001 U
Ethylbenzene	1,100/8,400/0.6	7,800/20,000	230/230	0.0066	0.001 U	0.001 U	0.001 U
Naphthalene	40/270/1.7	1,600/41,000	56/190	0.054	0.001 U	0.001 U	0.001 U
Toluene	380/2600/0.5	16,000/410,000	520/520	0.0019 I	0.0019 I	0.001 U	0.001 U
Xylenes, total *	5.9/22/0.2	160,000/4,100,000	210/210	0.0051 I	0.003 U	0.004 U	0.003 U
<p>NOTES:</p> <p>Constituent concentrations are presented in mg/kg.</p> <p>SCTLs taken from Table II; Florida Administrative Code (FAC) 62-777; August 1999</p> <p>RBCs taken from USEPA Region III.</p> <p>PRGs taken from USEPA Region IX.</p> <p>N/A - Not Available (The pages containing this information is missing from both copies provided to TtNUS.)</p> <p>Samples were also collected for SVOC (USEPA Method 8270) analyses; however, all were below laboratory detection limits</p> <p>* The laboratory analyzed for o- and m- and p- xylenes separately. They have been added here to present total xylenes for comparison to the regulatory levels.</p> <p>U - Not detected</p> <p>I - Analyte detected; value is between the Method Detection Limit and the Practical Quantitation Level.</p>							

leachability SCTLs; however, none exceeded the residential exposure SCTL. No SVOCs concentrations exceeded any current FDEP SCTL. Of the metals analyzed, only arsenic exceeded the FDEP residential SCTL (0.8 mg/kg) in sample JX00934 (17 mg/kg), JX00936 (0.9 mg/kg) and JX00937 (2.8 mg/kg). Only the concentration in the soil sample from JX00934 exceeded the SCTL industrial standard of 3.7 mg/kg. No other constituent exceeded its residential or industrial FDEP SCTL value. A summary of constituents detected in the samples from the ODA is provided in Table 3-7.

Two monitoring wells (MW-51-05 and MW-51-06) were installed downgradient of the source areas prior to the excavation activities and sampled for radiological contamination in June, August and October 1998. During the June 1998 sampling event only MW-51-05 was sampled. During this event, Radium-226 and Thorium-230 were detected at a concentration of 72.9 pCi/L. In August 1998, Radium-226 and Thorium-230 were detected at the same concentrations of 46.4 pCi/L (BEI sample ID JX01008 GWT) and 33.9 pCi/L (BEI sample ID JX01009 GWT) in the two wells. However, no information relating the sample identification number to the well number was available in the report. The results of the sampling reported by BEI to have occurred in October 1998 were not included in this document.

Chemical analyses of the groundwater from the two monitoring wells was performed on samples collected from April 1998 (pre-excavation) and November 1998 (post-excavation). The samples collected during these two events were sampled for VOCs by USEPA methods 601 and 602. The results of the April event reported detectable concentrations of cis-1,2-DCE, TCE and benzene in monitoring well MW-51-05. Of these only the benzene concentration of 2.2 µg/L exceeded groundwater criteria. The results from the November 1998 event reported detectable concentrations of cis-1,2-DCE, and TCE in MW-51-05 and methylene chloride in both wells. None of the concentrations exceeded groundwater criteria. The report was missing pages 3 through 5 of the laboratory report, however, which included a page with 10 compounds including benzene.

No conclusions or recommendations were made by BEI for PSC 51.

3.4 ADDITIONAL RADIOLOGICAL GROUNDWATER SAMPLING ACTIVITIES (BEI)

Since the installation of the two wells (MW-51-05 and MW-51-06) by BEI and issuance of the completion report, the USEPA requested additional sampling for Radium-226. To comply with the USEPA requirements, the Navy had BEI re-sample the subject wells. The results from the groundwater samples collected on July 28, 1999 reported a Radium-226 concentration of 2.2 pCi/L in MW-51-05 and a non-detect concentration in MW-51-06. The results from the March 10, 2000 sampling event reported

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Constituent	Regulatory Criteria			Sample ID and Date			
	FDEP SCTLs ¹ Residential/Industrial/ Leaching	USEPA RBCs ¹ Residential/Industrial	USEPA PRGs ¹ Residential/Industrial	JX00939	JX00940	JX00941	JX00942
				7/2/1998	7/2/1998	7/2/1998	7/2/1998
<u>Volatile Organic Compounds (mg/kg)</u>							
1,2,3-Trichlorobenzene	560/7400/4.6	NL	NL	0.16 U	0.16 U	0.16 U	0.2
1,2,4-Trimethylbenzene	13/88/0.3	3,900/100,000	5.7/5.7	8.1	1.3	4.6	
1,3,5-Trimethylbenzene	11/74/0.3	3,900/100,000	21/70	3.7	0.94	2.2	6
Benzene	1.1/1.6/.007	22/200	0.67/1.5	0.16 U	0.16 U	0.16 U	
Butylbenzene, n-		780/20,000	140/240	0.9	0.24 I	0.38 U	
Butylbenzene, s-		780/20,000	110/220	0.54	0.16 U	0.35 I	
Ethylbenzene	1100/8400/0.6	7,800/20,000	230/230	1.8	0.16 U	0.48	2.7
Hexachlorobutadiene	63/12/1.1	8.2/73	6.2/32	0.16 U	0.16 U	0.16 U	
Isopropylbenzene		NL	160/520	0.49 I	0.16 U	0.23 I	0.83
Isopropyltoluene, p-		NL	NL	0.95	0.23 I	0.58	
Naphthalene	40/270/1.7	1,600/41,000	56/190	4.9	0.73	2.6	
Propylbenzene, n-		NL	140/240	1.2	0.18	0.46	2.1
Toluene	380/2600/0.5	16,000/410,000	520/520	0.16 U	0.16 U	0.16 U	0.14 U
Xylenes, total *	5.9/22/0.2	160,000/4,100,000	210/210	9.4	0.91 I	3.2	14.8
<u>Semivolatile Organic Compounds (mg/kg)</u>							
1-Methylnaphthalene	68/470/2.2	NL	NL	1.3	0.46	0.81	
2-Methylnaphthalene	80/560/6.1	1,600/41,000	NL	2	0.7	1.1	
Naphthalene	40/270/1.7	1,600/41,000	56/190	0.43	0.42 U	0.42 U	
See notes at end of table.							

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	Regulatory Criteria			NASJAX BSCs mg/kg	Sample ID and Date			
	FDEP SCTLs ¹ Residential/Industrial/ Leaching mg/kg	USEPA RBCs ¹ Residential/Industrial mg/kg	USEPA PRGs ¹ Residential/Industrial mg/kg		JX00939	JX00940	JX00941	JX00942
					7/2/1998	7/2/1998	7/2/1998	7/2/1998
<u>Metals (mg/kg)</u>								
Arsenic	0.8/3.7/29	0.43/3.8	0.39/2.7	0.8	0.6 U	2 U	0.6 U	N/A
Barium	110/87000/1600	230/61000	30/64	6.6	40	36	43	N/A
Cadmium	75/1300/8	39/1000	37/810		1 U	1 U	1 U	N/A
Chromium	210/420/38	230/6100	30/64		15	15	13	N/A
Lead	400/920/**		400/1000	14.4	10	6.8	5.7	N/A
Mercury	3.4/26/2.1				0.01 U	0.01 U	0.014 I	N/A
Selenium	390/10000/5	3900/10000	390/10000		2 U	2 U	2 U	N/A
<p>NOTES:</p> <p>Concentrations presented above are in milligrams per kilogram (mg/kg). PRGs taken from USEPA Region IX</p> <p>SCTLs taken from Table II; FAC 62-777; August 1999. U - Not detected</p> <p>RBCs taken from USEPA Region III</p> <p>I - Analyte detected; value is between the Method Detection Limit and the Practical Quantitation Level</p> <p>NA - Not Available (The pages containing this information is missing from both copies provided to TtNUS.)</p> <p>* The laboratory analyzed for o- and m- and p- xylense separately. They have been added here to present total xylenes for comparison to the regulatory levels.</p> <p>** Leachability values may be derived using the Synthetic Precipitation Leaching Procedure (SPLP) Test to calculate site-specific SCTLs or may be determined using TCLP in the event oily wastes are present (FDEP, 1999).</p> <p>Bolded numbers indicate FDEP criteria exceedances.</p>								

Radium-226 concentrations of 6.62 pCi/L (MW-51-05) and 5.47 pCi/L (MW-51-06). Both concentrations were listed as estimated values by BEI.

3.5 QUARTERLY GROUNDWATER SAMPLING ACTIVITIES

TtNUS began performing monitoring of the two BEI monitoring wells in July 1999 for VOCs only. One monitoring event was performed on July 12, 1999 prior to the remedial investigation sampling documented in this report. Concentrations of cis-1,2-DCE, benzene, TCE, and vinyl chloride were detected in MW-51-05 with benzene and vinyl chloride exceeding Florida GCTLs. Benzene and methylene chloride were detected in the sample from MW-51-06 at concentrations below GCTLs.

4.0 RI/FS FIELD PROGRAM

4.1 OBJECTIVE AND APPROACH

The RI/FS field activities were conducted at PSC 51 between December 15 and 22, 1999 (initial scope) and August 21, 2001 to January 7, 2002 (additional field activities). The objective of the RI/FS field program was to obtain site specific information required to complete the RI/FS. To accomplish this, select members of the NAS Jacksonville Partnering Team created the initial scope of work implemented by TtNUS. The scope of work involved the following approach:

- Install nine monitoring wells at specified locations attempting to define the horizontal and vertical extents (zero-impact boundaries) of groundwater contamination.
- Sample new and existing PSC 51 monitoring wells and analyze the groundwater for TCL VOCs, SVOCs, and TAL metals.
- Collect surface soil, surface water, and sediment samples and analyze them for TAL metals or TCL VOCs as explained further in this section.
- Collect information through field tests and laboratory analyses to support a NA evaluation.

The following deviations occurred from the original Partnering Team scope of work listed above:

- During field activities, TtNUS installed only eight wells.
- The ninth well, which was the vertical extent well near MW-04, was not installed per conversations with the FDEP.
- These eight wells along with six (not the originally stated four) were sampled during the RI program.

Documents relating the previous sampling and cleanup of radiologically contaminated soil and groundwater were reviewed by both the FDEP and the USEPA. Based on the results of these efforts, the Partnering Team determined that radiological issues would not be addressed in this RI. Further, since soil was excavated to remove radiological and chemical contamination, the magnitude of soil investigation was significantly reduced.

After the initial scope of work was completed, a draft-final RI/FS was prepared and provided to Partnering Team in October 2000 for review. After the review of the draft RI/FS, the Partnering Team agreed that additional data collection was necessary. The additional field activities included the following:

- Collection of additional surface soil samples in the ODA to define surface soil arsenic contamination in excess of residential levels at PSC 51.
- Identify concentrations of TAL metal constituents in surface soil near the FFTA at PSC 51.
- Install an additional up-gradient well closer to MW-04.
- Define the vertical extent of contamination at PSC 51 near MW-04 and previous hydrocone sampling locations. In addition, define the horizontal extent in deeper intervals of the aquifer.
- Define the downgradient limits of the shallow groundwater contaminant plume. Assist the USGS in a determination of whether the groundwater from this area discharges into the unnamed creek that flows south of PSC 51 and to the community south of the station.

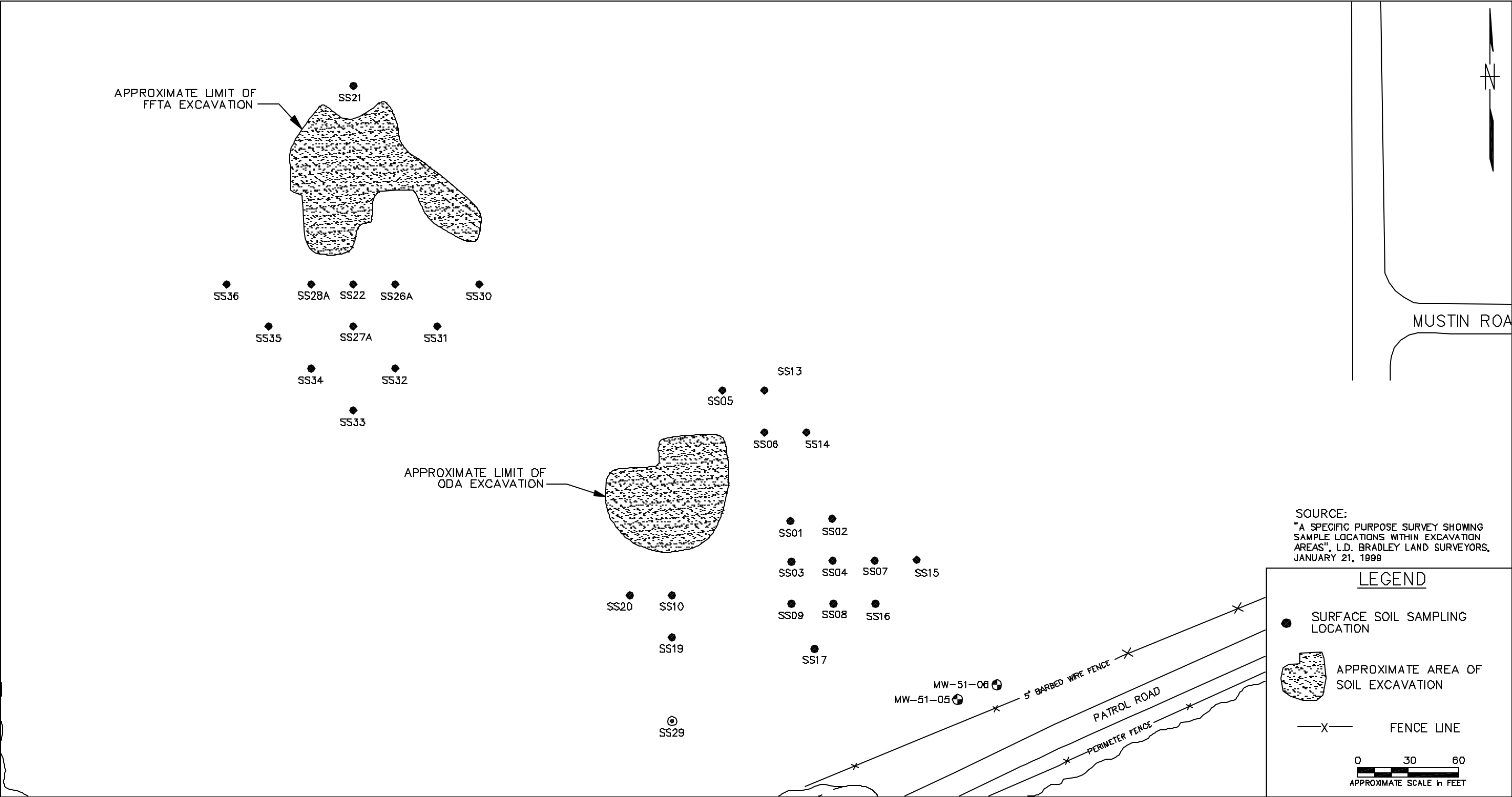
The additional scope of field activities were conducted between August 21, 2001 and January 7, 2002.

The last field event occurred due to the presence of total chromium in surface soil locations at concentrations that exceeded industrial SCTLs for hexavalent chromium. TtNUS field staff sampled surface soil at three locations, SS22, SS26A, and SS28A on July 16, 2002.


The following sections describe the field activities that took place during the RI investigation. Surface soil locations are presented on Figure 4-1. The surface water, sediment, and monitoring well locations are presented in Figure 4-2, and the DPT sample locations are indicated on Figure 4-3. Figure 3-1 presents the new and previously installed on-site monitoring wells that were sampled as part of the RI. The off-site monitoring wells are not included in Figure 3-1.

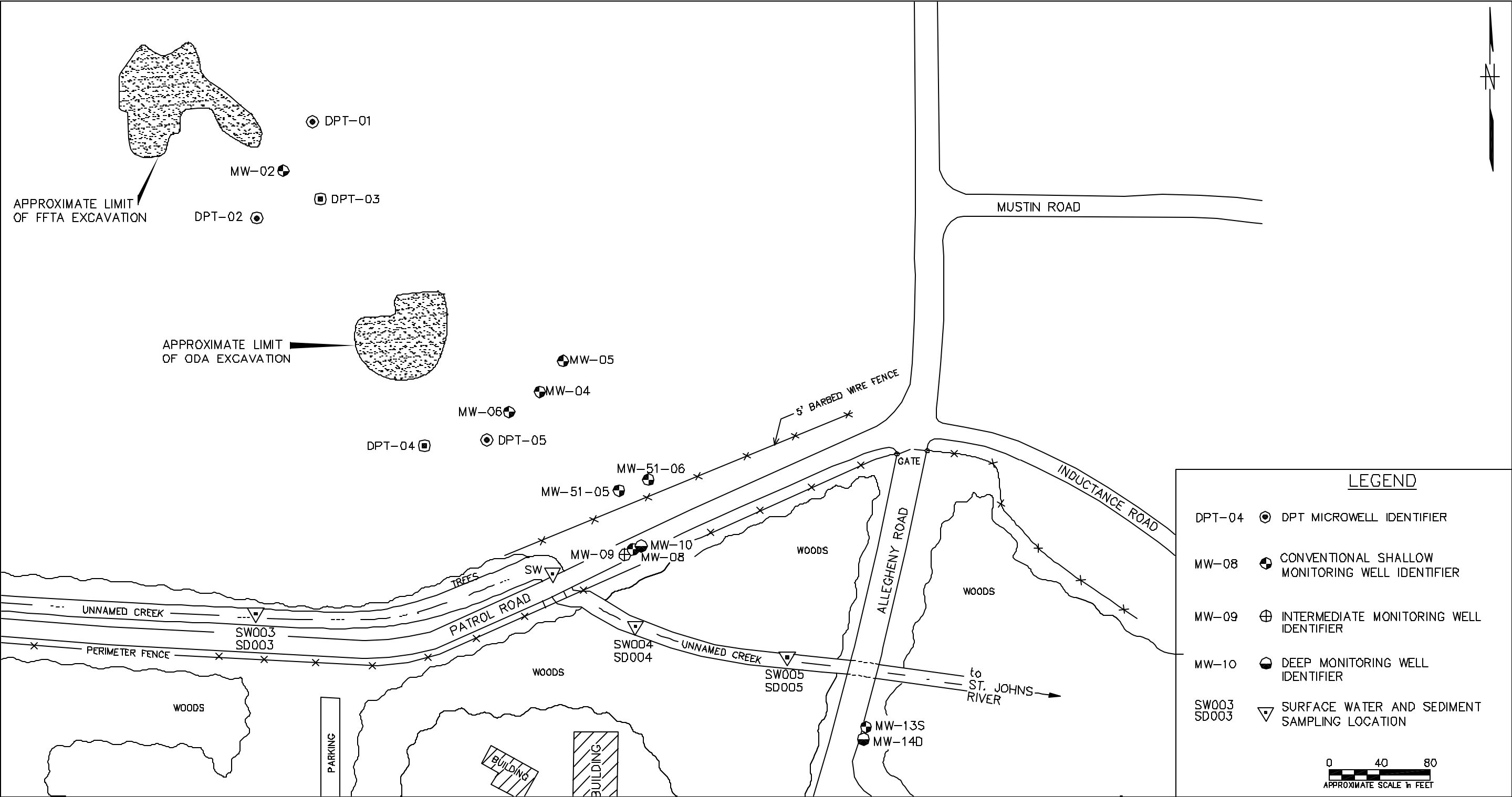
4.1.1 DPT Well Installation


Five DPT “micro” monitoring wells were installed, each to an approximate depth of 15 ft bls. These wells were installed at locations established during the RI planning effort to define the areal extent of groundwater contamination at the site. No soil sampling was performed during the installation of the DPT monitoring wells. Of the five wells, three (DPT-01, -02, and -03) were installed downgradient of the former FFTA surrounding previously installed MW-02. Two were installed south and southwest of the former ODA (DPT-04 and -05). Survey data for the new and previous monitoring well locations are

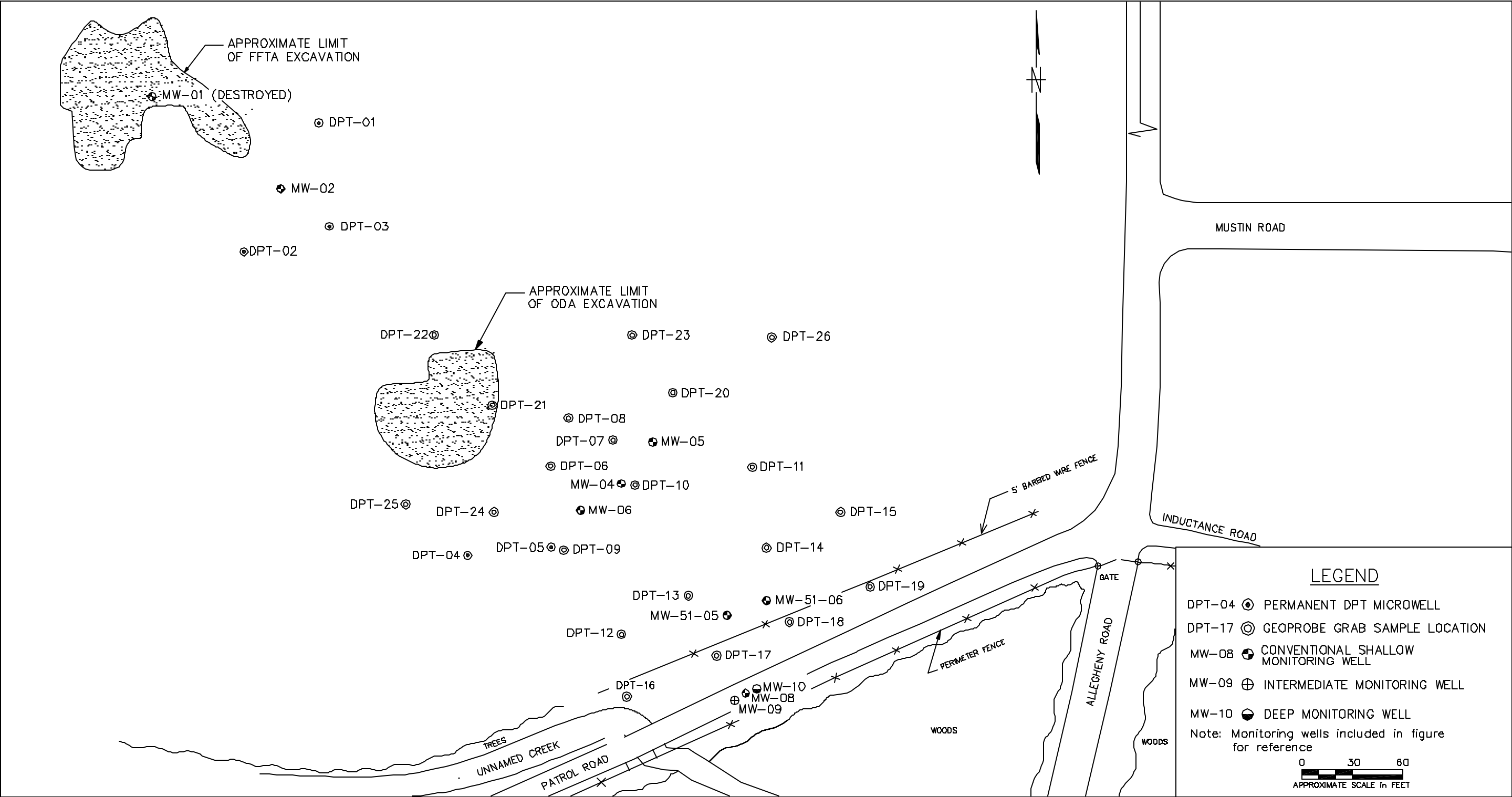



SOURCE:
"A SPECIFIC PURPOSE SURVEY SHOWING
SAMPLE LOCATIONS WITHIN EXCAVATION
AREAS", L.D. BRADLEY LAND SURVEYORS,
JANUARY 21, 1999

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		SURFACE SOIL SAMPLING LOCATIONS PSC 51 RI/FS NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. 0253	
							LLK	4/25/02			APPROVED BY	DATE
											CHECKED BY	DATE
							COST/SCHED-AREA				APPROVED BY	DATE
							SCALE				DRAWING NO.	REV.
							AS NOTED				FIGURE 4-1	0



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY CW	DATE 9/19/00		GROUNDWATER, SURFACE WATER, AND SEDIMENT RI SAMPLING LOCATIONS PSC 51 NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. N0253	
							CHECKED BY	DATE			APPROVED BY	DATE
							COST/SCHED-AREA					
							SCALE AS NOTED					
											DRAWING NO. FIGURE 4-2	REV. 0



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		RI DPT LOCATIONS PSC 51 NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. N0253	
							LLK	10/22/01			APPROVED BY	DATE
											APPROVED BY	DATE
							COST/SCHED—AREA					
							SCALE					
							AS NOTED					

provided in Appendix B. Soil boring logs and monitoring well installation documentation is provided in Appendix C.

For the additional field activities, the RI/FS Field Sampling Plan and Quality Assurance Project Plan Addendum (FSPQAPPA) (TtNUS, 2001) called for the installation of a DPT “micro” well in a more suitable location closer to MW-04 to assist in better plume definition in the upgradient direction. However, during DPT field activities at PSC 51, mobile lab results indicated that contaminants extended upgradient from MW-04 to close proximity with DPT-03 and, therefore, an additional DPT “micro” well was not installed since the DPT-03 well was determined to be located in a suitable upgradient location.

4.1.2 Hollow-stem Auguring Well Installation

The TtNUS RI/FS Field Sampling Plan (FSP) (TtNUS, 1999a) originally called for the installation of four 2-inch monitoring wells using hollow-stem auguring techniques. The wells (a single deep monitoring well located near MW-04 and three monitoring wells in a cluster along the patrol road) were intended to define the horizontal and vertical extent of groundwater contamination at the site. The single deep (double-cased) well near MW-04 was identified in the FSP as MW-07D. The three-well cluster, consisting of a shallow (15 ft bls) monitoring well (MW-08), an intermediate (35 ft bls) monitoring well (MW-09), and deep (50 ft bls) (double-cased) monitoring well (MW-10), was to be installed downgradient of PSC 51 near the southern boundary of NAS Jacksonville to detect any off-site migration of contaminants. MW-07D and MW-10 were originally intended to be screened in the aquifer sometimes present within the Hawthorn Group confining layer.

Monitoring wells MW-08 and MW-09 were installed according to the FSP. However, during installation of the soil boring for monitoring well MW-10, a clay confining unit was encountered at approximately 50 ft bls and extended to the boring termination of approximately 73 ft bls. A similar situation occurred when installing the soil boring for MW-07D, which was installed to a depth of approximately 64 ft bls, 14 ft into the confining unit. During the field effort, Mr. Gregory Roof of TtNUS spoke with Jorge Caspary of the FDEP and agreed on the following during these telephone conversations:

- The likelihood of contamination migrating below a confining unit with a thickness of more than 25 ft was remote.
- The original MW-10 would be abandoned and grouted to the surface.
- A new MW-10 would be installed in nearly the same location with the screen set near the top of the confining unit (approximately 50 ft bls).
- The MW-07D soil boring could be abandoned and not replaced.

Monitoring well MW-10 was re-drilled in close proximity to the original boring and screened from approximately 45 to 50 ft bls. Soil boring logs and monitoring well installation documentation are provided in Appendix C.

For the additional field activities conducted at PSC 51, the TtNUS FSPQAPPA (TtNUS, 2001) called for the installation of four additional 2-inch monitoring wells. The four additional monitoring wells were to be installed for downgradient plume delineation and to assist the USGS with groundwater modeling of the site with respect to the unnamed tributary.

The four monitoring wells (MW-11S, MW-12D, MW-13S, and MW-14D) were installed on August 21 and August 22, 2001, and were located with the assistance of the USGS. The location of the monitoring wells is presented on Figure 4-2. Monitoring well MW-11S was installed to a depth of 15 ft bls and screened from 5 to 15 ft bls. Monitoring well MW-12D was installed to a depth of 43 ft bls and screened from 38 to 43 ft bls. Monitoring well MW-13S was installed to a depth of 18 ft bls and screened from 8 to 18 ft bls. Monitoring well MW-14D was installed to a depth of 41.5 ft and screened from 36.5 to 41.5 ft bls. The monitoring wells were installed in accordance with the FSPQAPPA. Soil boring logs and monitoring well installation documentation are provided in Appendix C.

4.1.3 Monitoring Well Development

Monitoring wells were developed using peristaltic pumps ("micro" wells) and submersible pumps (conventional wells) within 24 hours of well installation. The wells were developed until the following criteria were achieved:

- Stabilization of the following parameters occurred.
 - Temperature plus or minus 1 degree Centigrade.
 - pH plus or minus 1 unit.
 - Electrical conductivity plus or minus 5 percent of scale.
- Turbidity remained within a 10 Nephelometric Turbidity Unit (NTU) range for 2 consecutive readings.
- A minimum of 3 well volumes was removed from the monitoring well.
- Accumulated sediment was removed from the well.

Discharge water color and volume were documented throughout the development. Monitoring well development records are provided in Appendix D.

4.1.4 Groundwater Level Measurements

Two rounds of synoptic groundwater level measurements were collected at PSC 51 on December 13, 1999 and October 2, 2001. The measurements were collected in order to determine the depth, flow direction, and gradient of groundwater. TtNUS also monitored the wells for free product while collecting water levels at PSC 51. No free product was encountered during the field efforts. The October 2, 2001 groundwater level measurements were collected from all monitoring wells including the wells located south of the unnamed creek and the groundwater data was submitted to the USGS for groundwater modeling of the site.

Figure 2-8 provides groundwater elevation and flow direction data for the December 13, 1999 gauging event, and Figure 2-9 is a graphical representation of the groundwater elevation and flow direction data for the October 2, 2001 gauging event. Based on the information displayed in the figures, groundwater generally flows to the southeast and has a steeper gradient nearer the Patrol Road and the unnamed creek. Groundwater level measurements are summarized in Table 4-1 and the Groundwater Level Measurement Sheets are included with the field forms in Appendix E.

The USGS modeling results are provided in Section 2.2.8.2 and Appendix A.

4.1.5 Monitoring Well Groundwater Sampling

Groundwater sampling at PSC 51 occurred between December 14 and 22, 1999 and September 26 to 28, 2001. The purpose of the December 1999 event was to define the aerial and vertical extent of groundwater contamination and collect data for evaluation of NA. Groundwater samples were collected from six existing and eight (three 2-inch diameter wells and five microwells) newly installed monitoring wells using low-flow purging and sampling techniques and analyzed for the following parameters: TCL VOCs (USEPA Method 8260B), TCL SVOCs (USEPA Method 8270), and TAL Metals (USEPA Method 6010B). Analytical results are discussed in Section 5.0. The validated laboratory data packages for all analyses are provided in Appendix F and the mobile laboratory data is presented in Appendix G.

Groundwater samples were also tested for NA evaluation purposes. The parameters analyzed in the field include carbon dioxide, dissolved (DO), dissolved inorganic carbon as alkalinity, ferrous iron, hydrogen sulfide, manganese, oxidation/reduction potential, pH, specific conductivity, and temperature. The NA parameters analyzed in the laboratory include alkalinity, chemical oxygen demand, chloride, dissolved sulfide, 5-day biochemical oxygen demand, fraction organic carbon (soil analysis), methane, ethane, ethene, nitrate, nitrite, ammonia, total kjeldahl nitrogen (TKN), ortho phosphate, sulfate, and total and dissolved iron and manganese. NA is discussed further in Section 5.0 of this report. The field analytical log sheets for geochemical parameters are provided in Appendix H.

Table 4-1
Water Table Elevation Data
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Well Number	Top of Casing Elevation (ft msl)	Screened Interval (ft bls)	Total Depth of Well 1 (ft bls)	December 13, 1999		October 2, 2001	
				Depth to Water Below Top of Casing (ft)	Water Elevation (ft msl)	Depth to Water Below Top of Casing (ft)	Water Elevation (ft msl)
MW-51-05 (a)	17.51	NA	15.38	2.80	14.71	2.62	14.89
MW-51-06 (a)	17.21	NA	26.2	3.35	13.86	2.2	15.01
MW-02 (b)	20.74	2.5 to 11.5	10.53	3.2	17.54	2.72	18.02
MW-04 (b)	18.28	2.5 to 11.5	10.67	2.53	15.75	2.51	15.77
MW-05 (b)	18.37	1 to 10	9.60	2.57	15.80	2.85	15.52
MW-06 (b)	18.09	1 to 10	9.03	2.35	15.74	2.32	15.77
MW-08S	17.91	3 to 13	13.25	4.29	13.62	3.54	14.37
MW-09I	18.05	28 to 33	39.05	4.02	14.03	3.04	15.01
MW-10D	17.9	45.5 to 50.5	49.76	4.23	13.67	2.95	14.95
MW-11S	17.49	5.5 to 15.5	15.62	NM	NM	1.76	15.73
MW-12D	17.67	38 to 43	43.34	NM	NM	2.72	14.95
MW-13S	16.45	8 to 18	18.31	NM	NM	7.54	8.91
MW-14D	16.51	36.5 to 41.5	41.61	NM	NM	6.26	10.25
DPT-01	21.12	6 to 15	15.07	3.15	17.97	2.84	18.28
DPT-02	20.26	6 to 15	15.07	2.85	17.41	2.12	18.14
DPT-03	20.28	6 to 15	15.07	2.95	17.33	2.53	17.75
DPT-04	18.23	5 to 14	13.42	2.25	15.98	2.02	16.21
DPT-05	18.13	4 to 13	12.08	2.41	15.72	3.15	14.98
Notes: ¹ Well depths are taken from well measurements collected on October 2, 2001. ² Bearings established from state plane coordinates, North American Datum 1983. NA - not available NM - not measured (a) - previously installed by BEI (b) - previously installed by HLA							

The wells were resampled during the September 2001 event along with the DPT investigation to define the horizontal and vertical extent of groundwater contamination. Groundwater samples were collected from nine existing monitoring wells and two newly installed monitoring wells. The wells were sampled using low-flow purging and sampling techniques and analyzed by the on-site mobile lab for benzene, toluene, ethylbenzene, xylenes, TCE, 1,2-DCE (cis and trans), vinyl chloride, and naphthalene by USEPA Method 8260B. The mobile laboratory data is presented in Appendix G. Field duplicate samples were collected from two of the monitoring wells and submitted to the fixed-based laboratory for analysis. Monitoring well locations are depicted on Figure 4-2.

4.1.6 Surface Water Sampling

Three surface water samples were collected from an unnamed creek located downgradient of PSC 51 on December 17, 1999. The creek has been identified as the primary receptor of groundwater emanating from PSC 51. The samples were analyzed for TCL VOCs in accordance with the FSP (TtNUS, 1999a). One additional surface water sample was collected on September 28, 2001 and analyzed by the on-site mobile lab for benzene, toluene, ethylbenzene, xylenes, TCE, 1,2-DCE (cis and trans), vinyl chloride, and naphthalene by USEPA Method 8260B. The surface water sample locations are depicted on Figure 4-2. Analytical results are discussed in Section 5.0. The validated laboratory data packages are presented in Appendix F and the mobile laboratory data is in Appendix G.

4.1.7 Sediment Sampling

Three sediment samples were collected from the unnamed creek at locations SD003, SD004, and SD005 near the southern perimeter of NAS Jacksonville on December 17, 1999. The samples were analyzed for TCL VOCs in accordance with the FSP (TtNUS, 1999a). The sediment sample locations are depicted on Figure 4-2. The sediment analytical results are discussed in Section 5.0, and the validated laboratory data packages are presented in Appendix F.

4.1.8 Surface Soil Sampling

The initial surface soil sampling activities occurred on December 19, 1999. Four soil samples, analyzed for inorganics, were collected at the ODA in order to verify removal of impacted soils and to provide information for the ecological and HHRAs performed for this RI. The samples were analyzed for TAL inorganics in accordance with the FSP (TtNUS, 1999a).

Due to detection of metals in excess of the FDEP SCTLs from the four surface soil samples collected during the initial RI process at PSC 51 and the resulting associated risk identified, data gaps existed which required additional investigation. Specifically, additional sampling was needed to complete the

delineation of arsenic in surface soil to residential levels near the ODA. In addition, surface soil sampling near the FFTA was required to determine the current concentrations of TAL metals. To complete the delineation of the arsenic impact to surface soil near the ODA, additional sampling of surface soil was performed at 14 sampling locations between October 10, 2001 and January 7, 2002. The soil was analyzed for arsenic by USEPA Method 6010. To determine the current concentrations of TAL metals at the FFTA, 12 soil samples were collected from near the FFTA for TAL metals analysis (USEPA Method 6010) between October 10, 2001 and January 7, 2002. The surface soil sample locations are indicated on Figure 4-1. The surface soil samples at PSC 51 were collected in accordance with the TtNUS FSPQAPPA (TtNUS, 2001).

The initial objective for the additional surface soil sampling activities in the ODA, was to delineate arsenic concentrations to the FDEP residential SCTL. However, the results of the additional sampling indicated the continued exceedance of arsenic above the FDEP residential SCTL. As a result, the Partnering Team agreed to the delineation of arsenic to the FDEP industrial SCTL. Statistical analysis was also used to evaluate the data set versus the industrial SCTL. Analytical results are discussed in Section 5.0.

Total chromium values were compared to the hexavalent chromium SCTLs. The results for locations SS22, SS26A and SS28A exceeded the industrial SCTL [410 milligrams per kilogram (mg/kg)] for hexavalent chromium. Therefore, additional surface soil samples were collected on July 26, 2002 and analyzed for hexavalent chromium. A discussion of the results of this additional sampling are included in Section 5.

4.1.9 Groundwater DPT Sampling with Mobile Laboratory Analysis

Groundwater DPT sampling and mobile laboratory analyses was performed to determine the horizontal and vertical extent of contaminant migration near MW-04 and the previous hydrocone sampling locations at depths of approximately 20 to 30 ft bls. To complete the delineation of the horizontal and vertical extent of contamination, borings were installed using DPT and groundwater samples were collected and analyzed via a mobile laboratory. The DPT sampling was conducted between September 25 and October 1, 2001, in accordance with the TtNUS FSPQAPPA (TtNUS, 2001). Historical VOC detections are presented on Figure 3-1. The location of the DPT borings conducted in September 2001 is presented on Figure 4-3.

Both the mobile laboratory and the fixed-based laboratory were used to analyze groundwater samples for the previously detected constituents, which include benzene, toluene, ethylbenzene, xylenes, TCE, 1,2-DCE (cis and trans), vinyl chloride, and naphthalene. Field duplicate samples were collected from ten percent of the samples and submitted to a fixed-based laboratory for analysis.

Initially, 14 DPT borings (DPT-06 through DPT-19) were proposed to delineate the horizontal extent of vertical migration. During the Additional RI Field activities, 21 DPT borings were installed to delineate the contaminant concentration at depth. DPT boring locations were adjusted based on the initial mobile laboratory results. The locations for the DPT borings are indicated on Figure 4-3.

The DPT effort included depth profiling of the contaminants. To accomplish this, DPT borings were advanced to depths up to 40 ft bls. Attempts were made to advance borings to a depth of 50 ft bls, however a weathered limestone with some clay was encountered between approximately 35 to 40 ft bls throughout the site. The weathered limestone resulted in DPT refusal. During DPT advancement groundwater samples were collected at 10-ft intervals and submitted to the mobile laboratory for analysis. Groundwater analytical results are discussed in Section 5.0.

5.0 NATURE AND EXTENT OF CONTAMINATION

This section summarizes and evaluates results of the sampling activities supporting the RI as described in Sections 3.0 and 4.0. Specifically, this section summarizes the nature and extent of impact to surface soil, groundwater, surface water, and sediment.

The quality of the chemical analytical data collected during the investigation of PSC 51 has been documented. With the exception of the mobile laboratory data, the analytical data validation process was completed for the fixed-based laboratory data packages in accordance with the USEPA Functional Guidelines for Organic Data Validation (February 1994), and the USEPA Functional Guidelines for Inorganic Data Validation (February 1994). The data set compiled using these guidelines, is considered acceptable for use in this RI and to support an FS. The mobile laboratory data was not validated. The validation summary reports for media sampled at PSC 51 are presented in Appendix F.

Contaminant sources are discussed in Section 5.1. Section 5.2 presents background screening concentrations using the results from the basewide background sampling program performed in support of the OU 1 RI/FS (ABB-ES, 1996). In Section 5.3, the nature and distribution of contamination throughout PSC 51 in the various media are presented and evaluated against background concentrations.

Discussion of the nature and extent of contamination at PSC 51 is structured according to the RI/FS guidance (USEPA, 1988). Sources of contamination are discussed first. Environmental media sampled during the investigation are then discussed in the following order: surface soil, surface water, sediment, and groundwater. Within each of these media, analytical fractions are discussed in the following order: VOCs, SVOCs, and inorganics. Following the evaluation of each analytical fraction for a particular medium, a summary of relevant results and findings is presented.

5.1 SOURCES OF CONTAMINATION

Sources of contamination at PSC 51 include the previous FFTA and ODA. The following paragraphs present a brief description of each identified source of contamination and the reported releases to the environment.

5.1.1 Fire Fighter Training Area

The FFTA was approximately 60 ft in diameter and is located north of the patrol road, which parallels the southern boundary of the base, and west of Allegheny Road approximately 250 ft northwest of the ODA. This area was formerly used by the base fire department as a practice fire fighting training area. Regular releases of organics occurred when fire fighters would discharge flammable materials onto the ground to support their training exercises. The flammable liquids that did not vaporize and burn would saturate the soil and eventually leach into the groundwater. Environmental impacts from these activities included VOC, SVOC, and inorganic contamination of soils and groundwater. Impacts to groundwater presumably resulted from either leaching or soil vapor transport from impacted soils or direct infiltration of impacted FFTA waste water.

A soil removal was conducted at the FFTA mitigating the potential for continued impacts to groundwater from leaching/soil vapor. Since the FFTA is no longer active and the contaminated soil has been removed, there appears to be no potential sources for continued impacts to groundwater.

5.1.2 Former Waste Oil Disposal Area

The ODA was approximately 50 ft in diameter and is located north of the patrol road and west of Allegheny Road. Reportedly operational from 1946 until 1952, the ODA was used to drain and dispose aircraft hydraulic fluids, fuels, and oils prior to being relocated to the DRMO located across Highway 17 (Roosevelt Blvd) from NAS Jacksonville (BEI, 1999). Releases to the environment occurred when these liquids were disposed onto the soil. There were no impervious surfaces or containment devices associated with this area. Environmental impacts from these activities included VOC, SVOC, and inorganic contamination of soils and groundwater. Impacts to groundwater presumably resulted from either leaching or soil vapor transport from impacted soils or direct infiltration of impacted ODA waste materials.

A soil removal was conducted at the ODA mitigating the potential for continued impacts to groundwater from leaching/soil vapor. Since the ODA is no longer active and the contaminated soil has been removed, there appears to be no potential sources for continued impacts to groundwater.

5.2 BACKGROUND SCREENING CONCENTRATIONS

Stationwide background concentrations for inorganic compounds in various environmental media were previously established and approved by FDEP and USEPA for NAS Jacksonville during the OU 1 RI/FS effort. These concentrations were developed using data gathered in areas that were representative of the facility and were believed to have not been impacted by NAS operations (ABB-ES, 1996).

Inorganic concentrations in all media sampled under this remedial investigation were evaluated against stationwide background values. No other site-specific background sampling was performed. The background concentrations for each COPC are presented along with the detections.

5.3 CONTAMINATION ASSESSMENT

This section discusses the data collected during the field investigation performed in support of the RI/FS, and is organized by media type.

5.3.1 Surface Soil

The initial RI scope of work included the collection and analysis of four surface soil samples near the southeast edge of the ODA excavation. The samples were analyzed for TAL metals only. During the additional RI activities in the Fall and Winter of 2001, 14 additional surface soil samples were collected from the ODA. The samples were analyzed for arsenic only. During the same timeframe 12 surface soil samples were collected from the FFTA. The samples were analyzed for TAL metals. In July 2002, three soil samples were collected from the FFTA and analyzed for hexavalent chromium. The analytical results and TtNUS' interpretation are included below.

5.3.1.1 Surface Soil Assessment Results

Four surface soil samples, analyzed for TAL inorganic compounds, were collected near the southeastern edge of the ODA excavation in accordance with the initial RI scope of work prepared by the Partnering Team. Fourteen additional surface soil samples were collected at the ODA to delineate arsenic to residential levels. In addition, surface soil sampling near the FFTA was performed to determine the current concentrations of TAL metals. Twelve surface soil samples were collected from the FFTA to determine current TAL metal concentrations. Three surface soil samples were collected and analyzed for hexavalent chromium at the three locations near the FFTA where total chromium analytical results exceeded the FDEP industrial SCTL for hexavalent chromium. Table 5-1 presents the summary of detections found in the 18 surface soil samples from the ODA with sample locations shown on Figure 4-1. Table 5-2 presents the summary of detections found in the 12 surface soil samples from the FFTA with sample locations also shown on Figure 4-1. The analytical results are provided in Appendix F. A discussion of the detections is presented below.

Table 5-1
TtNUS Surface Soil Analytical Detections Summary
Oil Disposal Area

Detected Constituent	FDEP SCTLs Residential/Industrial/ Leaching	USEPA Region III RBCs Residential/ Industrial	NASJAX Background Soil Concentrations	Sample ID, Date, and Depth			
				S001	S002	S003	S004
				12/17/1999 0-1ft	12/17/1999 0-1ft	12/17/1999 0-1ft	12/17/1999 0-1ft
INORGANICS (mg/kg)	mg/kg	mg/kg	mg/kg				
Aluminum	72,000/*/**	78,000/2,000,000	1,340	2580	2010	6410	5800
Antimony	26/240/5	31/820	None Listed	0.29 U	0.45	0.33	0.31 U
Arsenic	0.8/3.7/29	0.43/3.8	0.8	0.48 B	0.75	2.6	3.7
Barium	110/87,000/1600	5500/140,000	11.2	1.6	8.1	25.7	21
Cadmium	75/1300/8	39/1000	None Listed	0.02 U	0.33	2.2	0.27
Calcium	None Listed	None Listed	2,360	92.7 U	433	465	345
Chromium	210/410 ⁽¹⁾	12,000/3,100,000 ⁽²⁾	6.6	5.4	7.8	16	9.6
Cobalt	4700/110,000/**	1600/41,000	None Listed	0.08 U	0.28 U	0.93	0.83
Copper	110/76,000/**	3100/82,000	5.8	0.55 U	29.5	8.4	4 U
Iron	23,000/480,000/**	23,000/610,000	852	228	1090	6400	9620
Lead	400/920/**	None Listed	14.4	3.3	35.4	188	62.8
Magnesium	None Listed	None Listed	99.8	21 U	66.8 U	471	479
Manganese	1600/22,000/**	11000/290,000	99.8	1.7 U	9.5	10.1	5.9
Mercury	3.4/26/2.1	None Listed	None Listed	0.05	0.06	0.04	0.01
Nickel	110/28,000/130	1600/41000	11	0.47 U	2.6	2.2	1.8
Potassium	None Listed	None Listed	None Listed	21.8 U	41.3	209	161
Vanadium	15**/7,400/980	550/14,000	3.8	1.8	2.4	12.8	15.1
Zinc	23,000/560,000/6000	23,000/610,000	15.2	2 U	10.9	19.2	7.1

See notes at end of table.

Table 5-1 (Continued)
TtNUS Surface Soil Analytical Detections Summary
Oil Disposal Area

Detected Constituent	FDEP SCTLs Residential/Industrial/ Leaching	USEPA Region III RBCs Residential/ Industrial	NASJAX Background Soil Concentrations	Sample ID, Date, and Depth			
				SS09	SS10	SS13	SS14
				10/10/2001 0-1ft	10/10/2001 0-1ft	10/10/2001 0-1ft	10/10/2001 0-1ft
INORGANICS (mg/kg)	mg/kg	mg/kg	mg/kg				
Aluminum	72,000/*/**	78,000/2,000,000	1,340	NA	NA	NA	NA
Antimony	26/240/5	31/820	None Listed	NA	NA	NA	NA
Arsenic	0.8/3.7/29	0.43/3.8	0.8	0.35	2.3	0.84	0.27 U
Barium	110/87,000/1600	5500/140,000	11.2	NA	NA	NA	NA
Cadmium	75/1300/8	39/1000	None Listed	NA	NA	NA	NA
Calcium	None Listed	None Listed	2,360	NA	NA	NA	NA
Chromium	210/410 ⁽¹⁾	12,000/3,100,000 ⁽²⁾	6.6	NA	NA	NA	NA
Cobalt	4700/110,000/**	1600/41,000	None Listed	NA	NA	NA	NA
Copper	110/76,000/**	3100/82,000	5.8	NA	NA	NA	NA
Iron	23,000/480,000/**	23,000/610,000	852	NA	NA	NA	NA
Lead	400/920/**	None Listed	14.4	NA	NA	NA	NA
Magnesium	None Listed	None Listed	99.8	NA	NA	NA	NA
Manganese	1600/22,000/**	11000/290,000	99.8	NA	NA	NA	NA
Mercury	3.4/26/2.1	None Listed	None Listed	NA	NA	NA	NA
Nickel	110/28,000/130	1600/41000	11	NA	NA	NA	NA
Potassium	None Listed	None Listed	None Listed	NA	NA	NA	NA
Vanadium	15**/7,400/980	550/14,000	3.8	NA	NA	NA	NA
Zinc	23,000/560,000/6000	23,000/610,000	15.2	NA	NA	NA	NA
See notes at end of table.							

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	FDEP SCTLs Residential/Industrial/ Leaching	USEPA Region III RBCs Residential/ Industrial	NASJAX Background Soil Concentrations	Sample ID, Date, and Depth			
				SS15	SS16	SS17	SS19
				10/10/2001 0-1ft	10/10/2001 0-1ft	10/10/2001 0-1ft	10/10/2001 0-1ft
INORGANICS (mg/kg)	mg/kg	mg/kg	mg/kg				
Aluminum	72,000/*/**	78,000/2,000,000	1,340	NA	NA	NA	NA
Antimony	26/240/5	31/820	None Listed	NA	NA	NA	NA
Arsenic	0.8/3.7/29	0.43/3.8	0.8	0.34	0.48	0.38	1.8
Barium	110/87,000/1600	5500/140,000	11.2	NA	NA	NA	NA
Cadmium	75/1300/8	39/1000	None Listed	NA	NA	NA	NA
Calcium	None Listed	None Listed	2,360	NA	NA	NA	NA
Chromium	210/410 ⁽¹⁾	12,000/3,100,000 ⁽²⁾	6.6	NA	NA	NA	NA
Cobalt	4700/110,000/**	1600/41,000	None Listed	NA	NA	NA	NA
Copper	110/76,000/**	3100/82,000	5.8	NA	NA	NA	NA
Iron	23,000/480,000/**	23,000/610,000	852	NA	NA	NA	NA
Lead	400/920/**	None Listed	14.4	NA	NA	NA	NA
Magnesium	None Listed	None Listed	99.8	NA	NA	NA	NA
Manganese	1600/22,000/**	11000/290,000	99.8	NA	NA	NA	NA
Mercury	3.4/26/2.1	None Listed	None Listed	NA	NA	NA	NA
Nickel	110/28,000/130	1600/41000	11	NA	NA	NA	NA
Potassium	None Listed	None Listed	None Listed	NA	NA	NA	NA
Vanadium	15**/7,400/980	550/14,000	3.8	NA	NA	NA	NA
Zinc	23,000/560,000/6000	23,000/610,000	15.2	NA	NA	NA	NA
See notes at end of table.							

Table 5-1 (Continued)
TtNUS Surface Soil Analytical Detections Summary
Oil Disposal Area

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	FDEP SCTLs Residential/Industrial/ Leaching	USEPA Region III RBCs Residential/ Industrial	NASJAX Background Soil Concentrations	Sample ID, Date, and Depth	
				SS20 10/10/2001 0-1ft	SS29 1/7/2001 0-1ft
INORGANICS (mg/kg)	mg/kg	mg/kg	mg/kg		
Aluminum	72,000/*/**	78,000/2,000,000	1,340	NA	NA
Antimony	26/240/5	31/820	None Listed	NA	NA
Arsenic	0.8/3.7/29	0.43/3.8	0.8	0.24	0.34
Barium	110/87,000/1600	5500/140,000	11.2	NA	NA
Cadmium	75/1300/8	39/1000	None Listed	NA	NA
Calcium	None Listed	None Listed	2,360	NA	NA
Chromium	210/410 ⁽¹⁾	12,000/3,100,000 ⁽²⁾	6.6	NA	NA
Cobalt	4700/110,000/**	1600/41,000	None Listed	NA	NA
Copper	110/76,000/**	3100/82,000	5.8	NA	NA
Iron	23,000/480,000/**	23,000/610,000	852	NA	NA
Lead	400/920/**	None Listed	14.4	NA	NA
Magnesium	None Listed	None Listed	99.8	NA	NA
Manganese	1600/22,000/**	11000/290,000	99.8	NA	NA
Mercury	3.4/26/2.1	None Listed	None Listed	NA	NA
Nickel	110/28,000/130	1600/41000	11	NA	NA
Potassium	None Listed	None Listed	None Listed	NA	NA
Vanadium	15**/7,400/980	550/14,000	3.8	NA	NA
Zinc	23,000/560,000/6000	23,000/610,000	15.2	NA	NA
Notes: (1) The Chromium FDEP SCTL is for hexavalent Chromium. (2) The laboratory analysis performed was for total chromium, which does not have a Region III RBC. There are Region III RBCs for Chromium III (12,000/3,100,000) and Chromium IV (230.6100). SCTLs taken from Table II; FAC 62-777; August 1999 RBCs taken from USEPA Region III RBC Table, dated 4/13/00. B - Constituent also detected in a quality control (QC) blank. * Contaminant is not a health concern for this default exposure scenario (FDEP, 1999). ** Direct Exposure value based on acute toxicity considerations (FDEP, 1999). *** Leachability values may be derived using the SPLP Test to calculate site-specific SCTLs or may be determined using TCLP in the event oily wastes are present (FDEP, 1999). J - concentration was estimated U - non-detect NA - Not analyzed Bolded numbers indicate regulatory criteria exceedances.					

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Table 5-2 (Continued)
TtNUS Surface Soil Analytical Detections Summary
Fire Fighter Training Area

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Detected Constituent	FDEP SCTLs Residential/Industrial	USEPA Region III RBCs Residential/ Industrial	NASJAX Background Soil Concentrations	Sample ID, Date, and Depth					
				SS31	SS32	SS33	SS34	SS35	SS36
				1/7/2002 0-1 ft	1/7/2002 0-1 ft	1/7/2002 0-1 ft	1/7/2002 0-1 ft	1/7/2002 0-1 ft	1/7/2002 0-1 ft
INORGANICS (mg/kg)									
Aluminum	72,000/*	78,000/2,000,000	1,340	21400	34500	NA	NA	NA	NA
Antimony	26/240	31/820	None Listed	6.3	14.6	NA	NA	NA	NA
Arsenic	0.8/3.7	0.43/3.8	0.8	3.1	2.2 J	2.1	1.6	2.5 J	1.1
Barium	110/87,000	5500/140,000	11.2	54.3	108	NA	NA	NA	NA
Beryllium	120/800	160/4100	None Listed	NA	NA	NA	NA	NA	NA
Cadmium	75/1300	39/1000	None Listed	NA	NA	NA	NA	NA	NA
Calcium	None Listed	None Listed	2,360	1300	2630	NA	NA	NA	NA
Chromium	210/410 ⁽¹⁾	12,000/3,100,000 ⁽²⁾	6.6	188 J	362 J	313 J	377 J	225 J	22.1 J
Chromium (hexavalent) ⁽³⁾	210/410 ⁽¹⁾	12,000/3,100,000 ⁽²⁾	6.6	NA	NA	NA	NA	NA	NA
Cobalt	4700/110,000	1600/41,000	None Listed	NA	NA	NA	NA	NA	NA
Copper	110/76000	3100/82,000	5.8	1060 J	2360 J	2350 J	2840 J	1310 J	85.8 J
Iron	23,000/480,000	47,000/1,200,000	852	NA	NA	NA	19100	22200	4090
Lead	400/920	None Listed	14.4	214 J	366 J	NA	776 J	246 J	21.0 J
Magnesium	None Listed	None Listed	99.8	823 J	926 J	690 J	957 J	1070 J	406 J
Manganese	1600/22,000	1600/41,000	18	NA	NA	NA	NA	NA	NA
Mercury	3.4/26	None Listed	None Listed	NA	NA	NA	NA	NA	NA
Nickel	110/28,000	1600/41,000	11	80.6	146	145	165	67.8	12.0
Potassium	None Listed	None Listed	None Listed	NA	NA	NA	NA	NA	NA
Selenium	390/10,000	390/10,000	None Listed	NA	NA	NA	NA	NA	NA
Silver	390/9100	390/10,000	None Listed	NA	NA	NA	NA	NA	NA
Sodium	None Listed	None Listed	288	NA	NA	NA	NA	NA	NA
Vanadium	15**/7,400	550/14,000	3.8	29.8	16.5	18.4	16.5	26.9	NA
Zinc	23,000/560,000	23,000/610,000	15.2	NA	NA	NA	NA	NA	NA
NOTES:									
(1) The Chromium FDEP SCTL is for hexavalent Chromium.									
(2) The laboratory analysis performed was for total chromium, which does not have a Region III RBC. The Region III RBCs for Chromium III are listed.									
(3) Chromium (hexavalent) samples were collected on 07/16/02									
SCTLs taken from Table II; FAC 62-777; August 1999									
RBCs taken from USEPA Region III Criteria									
* Contaminant is not a health concern for this default exposure scenario (FDEP, 1999).									
NA = Not Analyzed									
** Direct Exposure value based on acute toxicity considerations (FDEP, 1999).									
Bolded numbers indicate regulatory criteria exceedances.									

5.3.1.2 Interpretation of Surface Soil Data

The NAS Jacksonville Partnering Team has reviewed the results of surface soil analyses to evaluate the need for potential future requirements. Part of this evaluation included potential future uses for the property. It has been determined that it is likely the property will remain as it currently exists (controlled access undeveloped land) or may be converted to an industrial property. As a result, it was determined that potential future actions should not be conducted in order to meet residential criteria. As a result, industrial criteria has been designated at the primary regulatory criteria for data evaluation purposes.

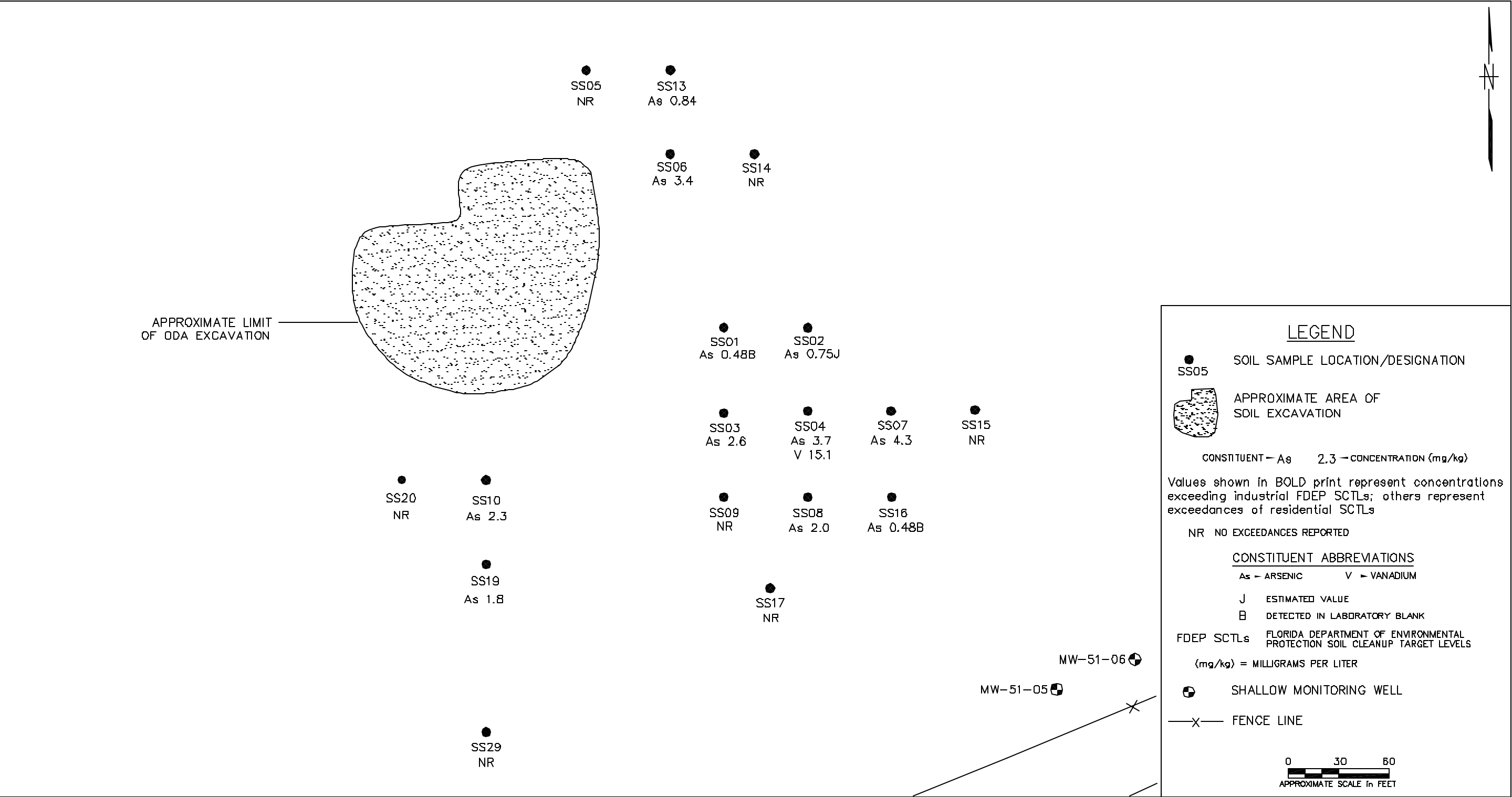
For the ODA and the FFTA, two metals (arsenic and lead) were detected in excess of the FDEP industrial SCTL values (3.8 mg/kg for arsenic and 920 mg/kg for lead) at a limited number of locations. Figures 5-1 and 5-2 provide the locations and constituent levels for soil samples which exceed SCTL values at the ODA and FFTA, respectively. Since the detections of these two metals at levels above the industrial SCTL values was limited in frequency with concentrations similar to SCTL values, statistical evaluation of the data was conducted to characterize the data set as a whole to determine if the site in its entirety poses an environmental risk by exceeding the industrial SCTL values.


Four statistical tools were used to perform this characterization. Detail regarding the statistical analysis results is provided in Appendix I.

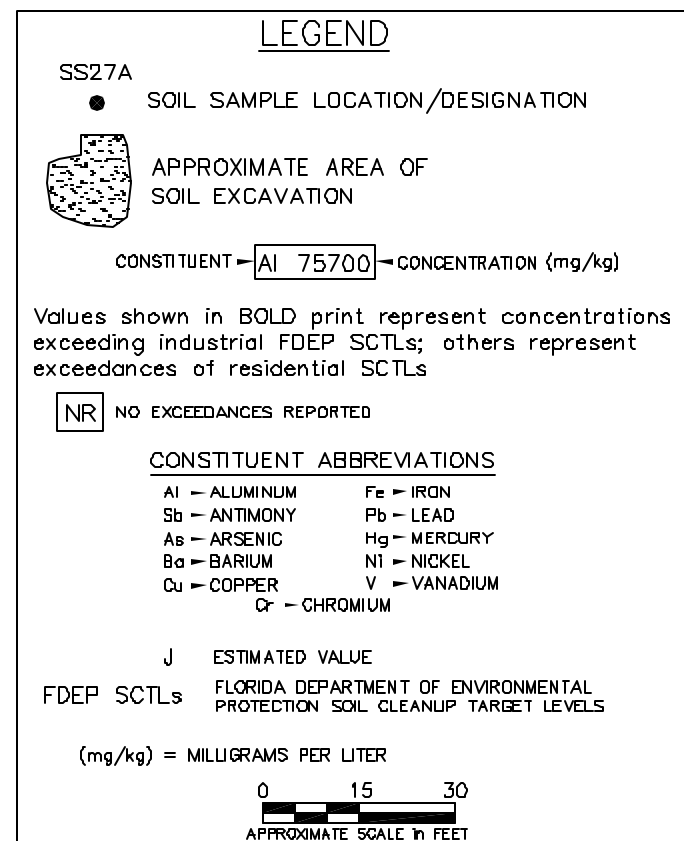
1. Descriptive statistics: These include the mean (average) concentration, standard deviation, and 95 percent upper confidence limit (UCL). If a data set is normally distributed, the one-sided 95 percent UCL represents the concentration that true mean concentration is no greater than with 95 percent confidence. If the 95 percent UCL is below the regulatory criteria one can be 95 percent certain that the average concentration across the site is below those criteria.
2. Box and whisker plots: Box and whisker plots show the central tendency, degree of symmetry, range of variation, and potential outliers of a data set.

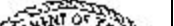
The upper value of the box in the box and whisker plot 75th percentile. The lower value of the box is the 25th percentile. Half the data falls between these two values.

The median (middle value) is represented by a small square in the box to indicate the middle point of the data.



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		SOIL ANALYTICAL RESULTS EXCEEDING APPLICABLE REGULATORY CRITERIA OIL DISPOSAL AREA PSC 51 RI/FS NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. 0253	
							LLK	3/22/01			APPROVED BY	DATE
							CHECKED BY	DATE			APPROVED BY	DATE
							COST/SCHED-AREA				DRAWING NO.	REV.
							SCALE				FIGURE 5-1	0
							AS NOTED					



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY LLK 4/26/02		SOIL ANALYTICAL RESULTS EXCEEDING APPLICABLE REGULATORY CRITERIA FORMER FIRE FIGHTER TRAINING AREA PSC 51 RI/FS NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. 0253	
							CHECKED BY DATE			APPROVED BY	DATE
							COST/SCHED--AREA			APPROVED BY	DATE
							SCALE				
							AS NOTED				
										DRAWING NO. FIGURE 5-2	REV. 0

The top of the whisker in the box and whisker plot is the 75th percentile plus 1.5 times the interquartile range, where the interquartile range is 75th percentile minus the 25th percentile. The bottom of the whisker in the box and whisker plot is the 25th percentile minus 1.5 times the interquartile range.

The range between the upper whisker value and the lower whisker value is the non-outlier range. Any value outside of this range is considered to be a statistical outlier. Statistical outliers are represented by an "O" on the plot. Statistical outliers that are more than one standard deviation from the non-outlier range are considered extreme values and represented by an asterisk (*). Statistical outliers and extreme values are suspiciously high values which may indicate that a mistake was made during the collection, handling, measurement, or documentation of the samples or that the result may be part of a different statistical population.

3. Histograms: a two-dimensional column plot of the frequency distribution of the data by concentration across the concentration range of the data set. These plots show the expected frequencies if the data were perfectly normally distributed, as well as the Shapiro-Wilk Test of Normality results on the data set. If the Wcalc value is greater than or equal to the Wtest value, the data is considered to be normally distributed.
4. Discordance Test: an outlier test recommended for between 3 and 50 samples to identify statistical outliers.

The results of these statistical analyses are summarized below:

FFTA

Arsenic: This data set contained only one value greater than the regulatory criteria of 3.8 mg/kg. Although this value (6.1 mg/kg at SS22) was shown by the discordance test to be a statistical outlier at greater than 95 percent confidence relative to the rest of the data set even without removing this outlier value, the 95 percent UCL of 2.98 mg/kg is below the regulatory criteria and the data set is normally distributed (as seen by the Wcalc value exceeding the Wtest value on the histogram). Based on this evaluation arsenic concentrations at the site conform to the FDEP industrial criteria.

Lead: This data set contained two values greater than the regulatory criteria of 920 mg/kg (1,130 mg/kg at SS22 and 1,190 mg/kg at SS26A). Neither of these results are outliers, the data set is normally distributed, and the 95 percent UCL of 685 mg/kg is below the regulatory criteria of 920 mg/kg. Based on this evaluation, lead concentrations at the site conform to the FDEP industrial criteria.

ODA

Arsenic: This data set contains three values above the regulatory criteria of 3.8 mg/kg (4.2 mg/kg at 51B00302, 4.3 mg/kg at SS07, and 17 mg/kg at JX00934). The highest value of 17 mg/kg is an extreme value and a statistical outlier with much greater than 99 percent confidence according to the discordance test. It skews the data set so it is not normally distributed, but rather a lognormal distribution. Even without removing this extreme value from the data set the lognormal 95 percent UCL of 2.69 mg/kg is below the regulatory criteria of 3.8 mg/kg. Based on this evaluation, arsenic concentrations at the site conform to the FDEP industrial criteria.

Lead: This data set contained only one value greater than the regulatory criteria of 920 mg/kg (1,030 mg/kg at 51B00402). Although this was shown by the discordance test to be a statistical outlier at greater than 99 percent confidence relative to the rest of the data set even without removing this outlier value, the 95 percent normal UCL of 256 mg/kg is well below the regulatory criteria of 920 mg/kg. Although the data set is not normally distributed but rather lognormally distributed, even the lognormal 95 percent UCL of 628 mg/kg is below the regulatory criteria of 920 mg/kg. Based on this evaluation, lead concentrations at the site conform to the FDEP industrial criteria.

Total chromium exceeded the FDEP industrial SCTL value for hexavalent chromium (410 mg/kg) at three locations at the FFTA (SS22, SS26A, and SS28A). As a result, additional sampling and analysis was performed at these locations and hexavalent chromium was not detected. Therefore, chromium is considered a COC, but only for the locations where the total chromium results exceed the residential SCTL but not the industrial SCTL.

5.3.2 Surface Water

For the initial RI activities, the Partnering Team agreed on three sampling points in the unnamed creek south of PSC 51. Three surface water samples (SW003 through SW005) were collected from the unnamed creek and analyzed for TCL VOCs only. SW003 through SW005 were used in the RI since HLA had previously collected two samples in the creek from different locations. One additional surface water sample, annotated Surface Water, was collected during the additional RI activities in September 2001. The additional surface water sample was collected and analyzed by the mobile laboratory for benzene, toluene, ethylbenzene, xylenes, TCE, 1,2-DCE (cis and trans), vinyl chloride, and naphthalene to determine VOCs concentrations in the creek in closer proximity to the groundwater VOC plume. The analytical results are discussed below.

5.3.2.1 Surface Water Assessment Results

A total of four surface water samples, analyzed for TCL VOCs, were collected from an unnamed creek located downgradient of PSC 51 (see Figure 4-2 for locations). The creek is the primary receptor of groundwater from PSC 51. Of the TCL VOCs analyzed, 2-butanone was detected in a single sample at location SW005 at a concentration of 0.7 µg/L.

5.3.2.2 Interpretation of Surface Water Data

The detection of 2-butanone was reported by the laboratory to be an estimated value. No other VOCs were detected in the surface water samples. The detection of 2-butanone was less than its respective FDEP surface water criteria of 120,000 µg/L, and should not present a significant environmental risk.

2-Butanone was also detected in the groundwater in some of the monitoring wells positioned upgradient of the creek. As a result, it is possible that the contaminated groundwater migration into the creek is responsible for the detection of 2-butanone in the single surface water sample.

5.3.3 Sediment

Sediment samples were collected at the same locations as the initial surface water samples previously discussed. The resulting samples were analyzed for TCL VOCs only. The results are presented below.

5.3.3.1 Sediment Assessment Results

Three sediment samples, analyzed for TCL VOCs, were collected in the unnamed creek located downgradient of PSC 51. The only VOC detection in sediment was 2-butanone (5.7 µg/kg) in the sample from location D004. No other VOCs were detected in the sediment samples.

5.3.3.2 Interpretation of Sediment Data

The contaminant detected in the sediment sample from D004 was also detected in the groundwater as discussed above. As a result, it is possible that the contaminated groundwater migration into the creek is contributing to the single detection in sediment. There are no Sediment Quality Assessment Guidelines (SQAGs) for the constituents detected in the sediment from D004.

5.3.4 Groundwater

Groundwater beneath PSC 51 has been evaluated in a series of investigative phases including sampling via DPT with mobile laboratory analyses and multiple rounds of monitoring well installations. Groundwater sample locations at PSC 51 are shown on Figure 4-2.

Groundwater samples collected from monitoring wells were analyzed for TCL VOCs and SVOCs and TAL metals. Previous sampling events did not detect PCBs or pesticides and, therefore, groundwater samples were not analyzed for PCBs or pesticide constituents as part of the RI investigation. Groundwater samples collected from DPT borings were analyzed via a mobile laboratory for VOC constituents and one PAH compound (naphthalene), based on previous detections of these chemical compounds.

5.3.4.1 Groundwater Assessment Results

Analytical results for organic constituents obtained from the mobile laboratory are provided in Table 5-3. Replicate groundwater sample results comparing mobile laboratory data to fixed-base laboratory data are provided on Table 5-4. Analytical results obtained for organic constituents from the fixed-base laboratory are provided on Table 5-5. Frequency of detection for organic constituents in groundwater obtained from the mobile laboratory is presented in Table 5-6. Frequency of detection for organic constituents in groundwater obtained from the fixed-based laboratory is presented in Table 5-7.

Inorganic analytical results are provided on Table 5-8. Frequency of detection for inorganic constituents is provided on Table 5-9. A brief synopsis of the results for each constituent class is provided below.

VOCs

A total of 15 VOCs were detected in groundwater at PSC 51. Of these, seven VOCs (benzene, 1,2-DCE, TCE, vinyl chloride, toluene, ethylbenzene, and xylenes) were detected at levels exceeding FDEP GCTLs. The highest frequency of detections exceeding GCTLs were obtained from samples collected in the vicinity of the ODA and in downgradient areas north of the unnamed creek.

SVOCs/PAHs.

A total of three SVOC/PAH compounds were detected in groundwater at PSC 51 with naphthalene being the only constituent that was detected above its respective GCTL. Naphthalene was detected at a maximum concentration of 120 µg/L at the ODA.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Table 5-4
TtNUS Replicate Groundwater Analytical Detections Summary - Organic Constituents
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Constituent	Regulatory Criteria		Well ID and Sample Date							
	FDEP GCTLs (mg/L)	USEPA MCLs (mg/L)	DPT-5 9/28/2001	MW-5 9/28/2001	DPT-6-39 9/28/2001	DPT-13-30 10/1/2001	DPT-18-40 10/1/2001	DPT-21-20 9/28/2001	DPT-23-20 9/28/2001	
VOLATILES (mg/L)										
Benzene	1	5	8	6	1 U	1 U	1 U	1 U	1 U	
cis-1,2-Dichloroethene	70	NL	3	12	2 U	2 U	2 U	2 U	2 U	
Ethylbenzene	30	700	1 U	1 U	1 U	1 U	1 U	1 U	1 U	
Naphthalene	20	NL	1 U	1 U	1 U	1 U	1 U	1 U	1 U	
Toluene	40	1000	1 U	1 U	1 U	1 U	1 U	1 U	1 U	
Trans-1,2-Dichloroethene	100	NL	2 U	2 U	2 U	2 U	2 U	2 U	2 U	
Trichloroethene	3	5	1 U	4	1 U	1 U	1 U	1 U	1 U	
Vinyl Chloride	1	2	2 J	1 U	1 U	1 U	1 U	1 U	1 U	
Xylenes (Total)	20	10000	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	
Notes: U - analyte was not detected J - estimated value NL - not listed										

Table 5-5
TtNUS Groundwater Analytical Detections Summary - Organic Constituents
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Constituent	Regulatory Criteria		Well ID and Sample Date					
	FDEP GCTLs (µg/L)	USEPA MCLs (µg/L)	MW-51-05 12/17/1999	MW-51-06 12/21/1999	DPT-01 12/14/1999	DPT-02 12/15/1999	DPT-03 12/14/1999 9/26/2001	
VOLATILE ORGANIC COMPOUNDS (µg/L)								
1,1,2,2-Tetrachloroethane	1.3	NL	1 U	1 U	1 U	1 U	1 U	NS
1,1-DCE	7	7	0.25 J	1 U	1 U	1 U	1 U	NS
1,2-Dichloroethane	3	5	0.33 J	1 U	1 U	1 U	1 U	NS
1,2-DCE (mixture)	63	NL	4.9	0.94 J	1 U	1 U	1 U	NS
2-Butanone	4,200	NL	10 U	10 U	10 U	10 U	10 U	NS
4-Methyl-2-Pentanone	560	NL	10 U	10 U	10 U	10 U	10 U	NS
Acetone	700	NL	10 U	10 U	10 U	10 U	10 U	NS
Benzene	1	5	1.3	1.6 J	1 U	1 U	1 U	1 U
Bromodichloromethane	0.6	100	1 U	1 U	1 U	1 U	1 U	NS
Carbon Disulfide	700	NL	1 U	1 U	1 U	1 U	0.14	NS
Chloroform	5.7	100	1 U	1 U	1 U	1 U	1 U	NS
Chloromethane	2.7	NL	2 U	2 U	2 U	2 U	2 U	NS
cis-1,2-DCE	70	70	NA	NA	NA	NA	NA	1 U
Ethylbenzene	30	700	1 U	1 U	1 U	1 U	1 U	1 U
Methylene Chloride	5	NL	1 U	1 U	1 U	1 U	1 U	NS
Toluene	40	1000	1 U	1 U	1 U	1 U	1 U	1 U
Trans-1,2-DCE	100	100	NA	NA	NA	NA	NA	1 U
TCE	3	5	1.2	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	1	2	2.9	2 U	2 U	2 U	2 U	1 U
Xylenes (Total)	20	10000	1 U	1 U	1 U	1 U	1 U	1 U
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)								
2,4-Dimethylphenol	140	NL	10 U	10 U	10 U	10 U	10 U	NS
2-Methylnaphthalene	20	NL	10 U	10 U	10 U	10 U	10 U	NS
Naphthalene	20	NL	10 U	10 U	10 U	10 U	10 U	1 U
POLYNUCLEAR AROMATICS (µg/L)								
1-Methylnaphthalene	20	NL	2 U	2 U	2.1 U	2 U	2 U	NS
2-Methylnaphthalene	20	NL	2 U	2 U	2.1 U	2 U	2 U	NS
Indeno(1,2,3-cd)Pyrene	0.2	NL	0.1 U	0.1 U	0.05 J	0.1 U	0.1 U	NS
Naphthalene	20	NL	2 U	2 U	2.1 U	2 U	2 U	NS
See notes at end of table.								

Table 5-5 (Continued)
TtNUS Groundwater Analytical Detections Summary - Organic Constituents
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Constituent	Regulatory Criteria		Well ID and Sample Date					
	FDEP GCTLs (µg/L)	USEPA MCLs (µg/L)	DPT-04		DPT-05		MW-02	
			12/17/1999	9/27/2001	12/16/1999	9/28/2001	12/15/1999	
VOLATILE ORGANIC COMPOUNDS (µg/L)								
1,1,2,2-Tetrachloroethane	1.3	NL	1 U	NS	1 U	NS	1 U	
1,1-DCE	7	7	1 U	NS	1 U	NS	1 U	
1,2-Dichloroethane	3	5	1 U	NS	1 U	NS	1 U	
1,2-DCE (mixture)	63	NL	1.1	NS	2	NS	1 U	
2-Butanone	4,200	NL	10 U	NS	10 U	NS	10 U	
4-Methyl-2-Pentanone	560	NL	10 U	NS	10 U	NS	10 U	
Acetone	700	NL	10 U	NS	10 U	NS	10 U	
Benzene	1	5	1 U	1 U	6.2	8.2	1 U	
Bromodichloromethane	0.6	100	1 U	NS	1 U	NS	1 U	
Carbon Disulfide	700	NL	1.1	NS	1 U	NS	1 U	
Chloroform	5.7	100	1 U	NS	1 U	NS	1 U	
Chloromethane	2.7	NL	2 U	NS	2 U	NS	2 U	
cis-1,2-DCE	70	70	NA	1 U	NA	3.5	NA	
Ethylbenzene	60	700	1 U	1 U	0.77 J	1 U	1 U	
Methylene Chloride	5	NL	1 U	NS	1 U	NS	1 U	
Toluene	40	1000	1 U	1 U	1 U	1 U	1 U	
Trans-1,2-DCE	100	100	NA	1 U	NA	1 U	NA	
TCE	3	5	0.097 J	1 U	1 U	1 U	1 U	
Vinyl Chloride	1	2	2 U	1 U	2.6	1.9	2 U	
Xylenes (Total)	20	10000	1 U	1 U	2.3	1 U	1 U	
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)								
2,4-Dimethylphenol	140	NL	10 U	NS	10 U	NS	10 U	
2-Methylnaphthalene	20	NL	10 U	NS	10 U	NS	10 U	
Naphthalene	20	NL	10 U	1 U	10 U	1 U	10 U	
POLYNUCLEAR AROMATICS (µg/L)								
1-Methylnaphthalene	20	NL	2 U	NS	2 U	NS	2 U	
2-Methylnaphthalene	20	NL	2 U	NS	0.57 J	NS	2 U	
Indeno(1,2,3-cd)Pyrene	0.2	NL	0.1 U	NS	0.1 U	NS	0.1 U	
Naphthalene	20	NL	2 U	NS	0.69 J	NS	2 U	
See notes at end of table.								

Table 5-5 (Continued)
TtNUS Groundwater Analytical Detections Summary - Organic Constituents
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Constituent	Regulatory Criteria		Well ID and Sample Date					
	FDEP GCTLs (µg/L)	USEPA MCLs (µg/L)	MW-04			MW-05		
			12/16/1999	9/28/2001		12/15/1999	9/28/2001	
VOLATILE ORGANIC COMPOUNDS (µg/L)								
1,1,2,2-Tetrachloroethane	1.3	NL	5	U	NS	1	U	NS
1,1-DCE	7	7	1.2	J	NS	0.25	J	NS
1,2-Dichloroethane	3	5	5	U	NS	1	U	NS
1,2-DCE (mixture)	63	NL	64		NS	3.8		NS
2-Butanone	4,200	NL	50	U	NS	10	U	NS
4-Methyl-2-Pentanone	560	NL	50	U	NS	10	U	NS
Acetone	700	NL	50	U	NS	10	U	NS
Benzene	1	5	120		2.7	3.4		4.9
Bromodichloromethane	0.6	100	5	U	NS	1	U	NS
Carbon Disulfide	700	NL	5	U	NS	1	U	NS
Chloroform	5.7	100	5	U	NS	1	U	NS
Chloromethane	2.7	NL	10	U	NS	2	U	NS
cis-1,2-DCE	70	70	NA		1.3	NA		9.2
Ethylbenzene	60	700	20		1 U	1	U	1 U
Methylene Chloride	5	NL	5	U	NS	1	U	NS
Toluene	40	1000	2.8	J	1 U	1	U	1 U
Trans-1,2-DCE	100	100	NA		1 U	NA		1 U
TCE	3	5	4.7	J	1 U	2.7		2.8
Vinyl Chloride	1	2	10	U	1 U	2	U	1 U
Xylenes (Total)	20	10000	20		1 U	1	U	1 U
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)								
2,4-Dimethylphenol	140	NL	2.8	J	NS	10	U	NS
2-Methylnaphthalene	20	NL	20		NS	10	U	NS
Naphthalene	20	NL	31		1.4	10	U	1 U
POLYNUCLEAR AROMATICS (µg/L)								
1-Methylnaphthalene	20	NL	10		NS	2	U	NS
2-Methylnaphthalene	20	NL	18		NS	2	U	NS
Indeno(1,2,3-cd)Pyrene	0.2	NL	0.1	U	NS	0.1	U	NS
Naphthalene	20	NL	30		NS	2	U	NS
See notes at end of table.								

Table 5-5 (Continued)
TtNUS Groundwater Analytical Detections Summary - Organic Constituents
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Constituent	Regulatory Criteria		Well ID and Sample Date										
	FDEP GCTLs (µg/L)	USEPA MCLs (µg/L)	MW-06		MW-08		MW-09						
			12/16/1999	9/27/2001	12/22/1999	9/26/2001	12/22/1999	9/26/2001					
VOLATILE ORGANIC COMPOUNDS (µg/L)													
1,1,2,2-Tetrachloroethane	1.3	NL	1	U	NS	1	U	NS	1	U	NS		
1,1-DCE	7	7	0.2	J	NS	1	U	NS	1	U	NS		
1,2-Dichloroethane	3	5	1	U	NS	1	U	NS	1	U	NS		
1,2-DCE (mixture)	63	NL	5.8		NS	3.2		NS	1	U	NS		
2-Butanone	4,200	NL	10	U	NS	10	U	NS	10	U	NS		
4-Methyl-2-Pentanone	560	NL	10	U	NS	10	U	NS	10	U	NS		
Acetone	700	NL	10	U	NS	10	U	NS	10	U	NS		
Benzene	1	5	11		27.8	4	J	1	U	1	U		
Bromodichloromethane	0.6	100	1	U	NS	1	U	NS	1	U	NS		
Carbon Disulfide	700	NL	1	U	NS	1	U	NS	0.36	J	NS		
Chloroform	5.7	100	1	U	NS	1	U	NS	1.4		NS		
Chloromethane	2.7	NL	2	U	NS	2	U	NS	2	U	NS		
cis-1,2-DCE	70	70	NA		14.6	NA		1.4	NA		1	U	
Ethylbenzene	30	700	1.4		6.1	1	U	1	U	1	U	U	
Methylene Chloride	5	NL	1	U	NS	1	U	NS	1	U	NS		
Toluene	40	1000	1	U	1	U	1	U	1	U	1	U	
Trans-1,2-DCE	100	100	NA		1	U	NA		1	U	NA	1	U
TCE	3	5	0.13	J	1	U	1.1		1	U	1	U	U
Vinyl Chloride	1	2	1.5	J	2.3	2.2		1	U	2	U	1	U
Xylenes (Total)	20	10000	1		4.2	1	U	1	U	1	U	1	U
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)													
2,4-Dimethylphenol	140	NL	10	U	NS	10	U	NS	10	U	NS		
2-Methylnaphthalene	20	NL	10	U	NS	10	U	NS	10	U	NS		
Naphthalene	20	NL	1.7	J	3.5	10	U	2.4	10	U	1	U	
POLYNUCLEAR AROMATICS (µg/L)													
1-Methylnaphthalene	20	NL	0.44	J	NS	2	U	NS	2	U	NS		
2-Methylnaphthalene	20	NL	0.91	J	NS	2	U	NS	2	U	NS		
Indeno(1,2,3-cd)Pyrene	0.2	NL	0.1	U	NS	0.1	U	NS	0.1	U	NS		
Naphthalene	20	NL	1.4	J	NS	2	U	NS	2	U	NS		
See notes at end of table.													

Table 5-5 (Continued)
TtNUS Groundwater Analytical Detections Summary - Organic Constituents
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Constituent	Regulatory Criteria		Well ID and Sample Date					
	FDEP GCTLs (µg/L)	USEPA MCLs (µg/L)	MW-10		MW-13S		MW-14D	
			12/21/1999	9/26/2001	9/27/2001		9/27/2001	
VOLATILE ORGANIC COMPOUNDS (µg/L)								
1,1,2,2-Tetrachloroethane	1.3	NL	1 U	NS	NS		NS	
1,1-DCE	7	7	1 U	NS	NS		NS	
1,2-Dichloroethane	3	5	1 U	NS	NS		NS	
1,2-DCE (mixture)	63	NL	1 U	NS	NS		NS	
2-Butanone	4,200	NL	2.5 J	NS	NS		NS	
4-Methyl-2-Pentanone	560	NL	0.79 J	NS	NS		NS	
Acetone	700	NL	21 J	NS	NS		NS	
Benzene	1	5	2 J	4.8	1 U		1 U	
Bromodichloromethane	0.6	100	1 U	NS	NS		NS	
Carbon Disulfide	700	NL	13	NS	NS		NS	
Chloroform	5.7	100	0.86 J	NS	NS		NS	
Chloromethane	2.7	NL	2 U	NS	NS		NS	
cis-1,2-DCE	70	70	NA	1.5	1 U		1 U	
Ethylbenzene	30	700	0.17 J	1 U	1 U		1 U	
Methylene Chloride	5	NL	0.27 J	NS	NS		NS	
Toluene	40	1000	1.7	1 U	1 U		1 U	
Trans-1,2-DCE	100	100	NA	1 U	1 U		1 U	
TCE	3	5	1 U	1 U	1 U		1 U	
Vinyl Chloride	1	2	2 U	1 U	1 U		1 U	
Xylenes (Total)	20	10000	2.3	1 U	1 U		1 U	
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)								
2,4-Dimethylphenol	140	NL	10 U	NS	NS		NS	
2-Methylnaphthalene	20	NL	10 U	NS	NS		NS	
Naphthalene	20	NL	10 U	1 U	1 U		1 U	
POLYNUCLEAR AROMATICS (µg/L)								
1-Methylnaphthalene	20	NL	2 U	NS	NS		NS	
2-Methylnaphthalene	20	NL	2 U	NS	NS		NS	
Indeno(1,2,3-cd)Pyrene	0.2	NL	0.1 U	NS	NS		NS	
Naphthalene	20	NL	2 U	NS	NS		NS	
Notes: U - analyte was not detected J - estimated value NL - not listed NS - not sampled								

Table 5-6
Mobile Laboratory Frequency and Range of Organic Compound Detections in Groundwater
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Analyte/Compound	Frequency of Detection ¹	Range of Detected Concentrations	Arithmetic Mean of Positive Detections ²
<u>Volatile Organic Compounds (µg/L)</u>			
cis-1,2-DCE	24/80	1.3 to 110	19.9
trans-1,2-DCE	2/80	1.0 to 2.8	1.9
Benzene	23/80	1.0 to 240	33.2
Ethylbenzene	8/80	1.7 to 85	22.3
Toluene	7/80	1.0 to 470	78.7
TCE	14/80	1.1 to 78	15.3
Vinyl chloride	10/80	1.9 to 37.3	10.8
Xylenes (total)	9/80	1.8 to 380	65.2
<u>Semivolatile Organic Compounds (µg/L)</u>			
Naphthalene	22/80	1.0 to 120	16.0
Data set summarized above includes groundwater samples taken from monitoring wells DPT-03 through DPT-05, MW-04, MW-05, MW-06, MW-08S, MW-09I, MW-10D, MW-13S, MW-14D, and DPT borings DPT-6 through 26 (including all depths) during the additional RI field investigation activities conducted from in September 25, 2001 to October 1, 2001.			
Notes: ¹ Frequency of detection is the number of groundwater samples in which the analyte was detected divided by the total number of samples analyzed. ² The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.			

Table 5-7
Frequency and Range of Organic Compound Detections in Groundwater From Monitoring Wells
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Analyte/Compound	Frequency of Detection ¹	Range of Detected Concentrations	Arithmetic Mean of Positive Detections ²
<u>Volatile Organic Compounds (mg/L)</u>			
1,1-DCE	4/14	0.25 to 1.2	0.48
1,2-Dichloroethane	1/14	0.33	0.33
1,2-DCE	8/14	0.94 to 64	10.72
2-butanone	1/14	2.5	2.50
4-methyl-2-pentanone	1/14	0.79	0.79
Acetone	1/14	21	21.0
Benzene	8/14	1.3 to 120	18.69
Carbon disulfide	4/14	0.14 to 13	3.65
Chloroform	2/14	0.86 to 1.4	1.13
Ethylbenzene	4/14	0.17 to 20	5.59
Methylene Chloride	1/14	0.27	0.27
Toluene	2/14	1.7 to 2.8	2.25
TCE	6/14	0.097 to 4.7	1.65
Vinyl chloride	4/14	1.5 to 2.9	2.30
Xylenes (total)	4/14	1 to 20	6.25
<u>Semivolatile Organic Compounds (mg/L)</u>			
2,4-dimethylphenol	1/14	2.8	2.8
2-methylnaphthalene	1/14	20	20
Naphthalene	2/14	1.7 to 31	16.35
<u>Polynuclear Aromatic Hydrocarbons (mg/L)</u>			
1-methylnaphthalene	2/14	0.44 to 10	5.22
2-methylnaphthalene	3/14	0.57 to 18	6.49
Indeno(1,2,3-cd)pyrene	1/14	0.05	0.05
Naphthalene	3/14	0.69 to 30	10.7
Data set summarized above include groundwater samples taken from monitoring wells MW-51-05, MW-51-06, DPT-01 through DPT-05, MW-02, MW-04, MW-05, MW-06, MW-08S, MW-09I, MW-10D during the RI field investigation activities conducted from December 14, 1999 through December 21, 1999.			
<p>Notes:</p> <p>¹Frequency of detection is the number of groundwater samples in which the analyte was detected divided by the total number of samples analyzed.</p> <p>²The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected. Estimated (J) values between the method reporting limit and the equipment detection capabilities were included in this calculation.</p>			

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Notes at end of table.

Table 5-9
Frequency and Range of Inorganic Compound Detections in Groundwater
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Analyte/Compound	Frequency of Detection ¹	Range of Detected Concentrations	Arithmetic Mean of Positive Detections ²
<u>Inorganics (µg/L)</u>			
Aluminum	11/14	109 to 3,190	735
Barium	14/14	26.6 to 126	64.7
Cadmium	2/14	2.6 to 2.9	2.75
Calcium	14/14	980 to 112,000	22,753.6
Chromium	2/14	2.8 to 3.0	2.9
Copper	7/14	1.7 to 8	4.23
Iron	14/14	154 to 5,560	1,425
Lead	2/14	1.8 to 4.2	3.0
Magnesium	14/14	803 to 33,300	4,532
Manganese	11/14	14.3 to 119	44.61
Nickel	9/14	1.3 to 4.3	3.14
Potassium	14/14	521 to 7,060	2,553
Sodium	14/14	4,470 to 19,600	11,415
Vanadium	8/14	0.51 to 6.5	2.11
Data set summarized above include groundwater samples taken from monitoring wells MW-51-05, MW-51-06, DPT-01 through DPT-05, MW-02, MW-04, MW-05, MW-06, MW-08, MW-09, MW-10 during RI field investigation, December 1999.			
Notes: ¹ Frequency of detection is the number of groundwater samples in which the analyte was detected divided by the total number of samples analyzed. ² The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.			

Inorganics

Fourteen inorganics were detected in groundwater at PSC 51. Of these, three constituents (aluminum, iron, and manganese) were detected at levels above their respective GCTLs. However, each of these detections is below its respective NAS basewide background screening value.

5.3.4.2 Interpretation of Groundwater Data

The lateral and vertical extent of organic constituents exceeding GCTLs are provided on Figures 5-3 through 5-18. A map view of the lateral extent and levels of each of these constituents is provided on a figure followed by a second figure depicting a three dimensional model of the constituent's extent. Interpretation of the data is provided by constituent class in the following text.

VOCs

Both fuel-related VOC constituents (benzene, ethylbenzene, toluene, and xylenes) and chlorinated solvent VOC constituents (TCE, cis-1,2-DCE, and vinyl chloride) were detected at PSC 51 with the maximum detections associated with the ODA. This class of constituents is consistent with the historical use of both the FFTA and the ODA. The detected levels of these constituents is generally within an order of magnitude or less of their respective GCTLs indicating that these constituents may be degradable via NA processes. The distribution of these constituents (Figures 5-3 through 5-16) indicates that the ODA served as the primary source for groundwater contamination at PSC 51 prior to the excavation of impacted soils.

The lateral extent of VOC constituents has been defined with the downgradient extent limited by the unnamed creek to the southeast of the ODA. Monitoring wells nearest the creek contain benzene and vinyl chloride at levels slightly exceeding their respective GCTLs. Wells installed beyond the creek do not contain detectable constituents.

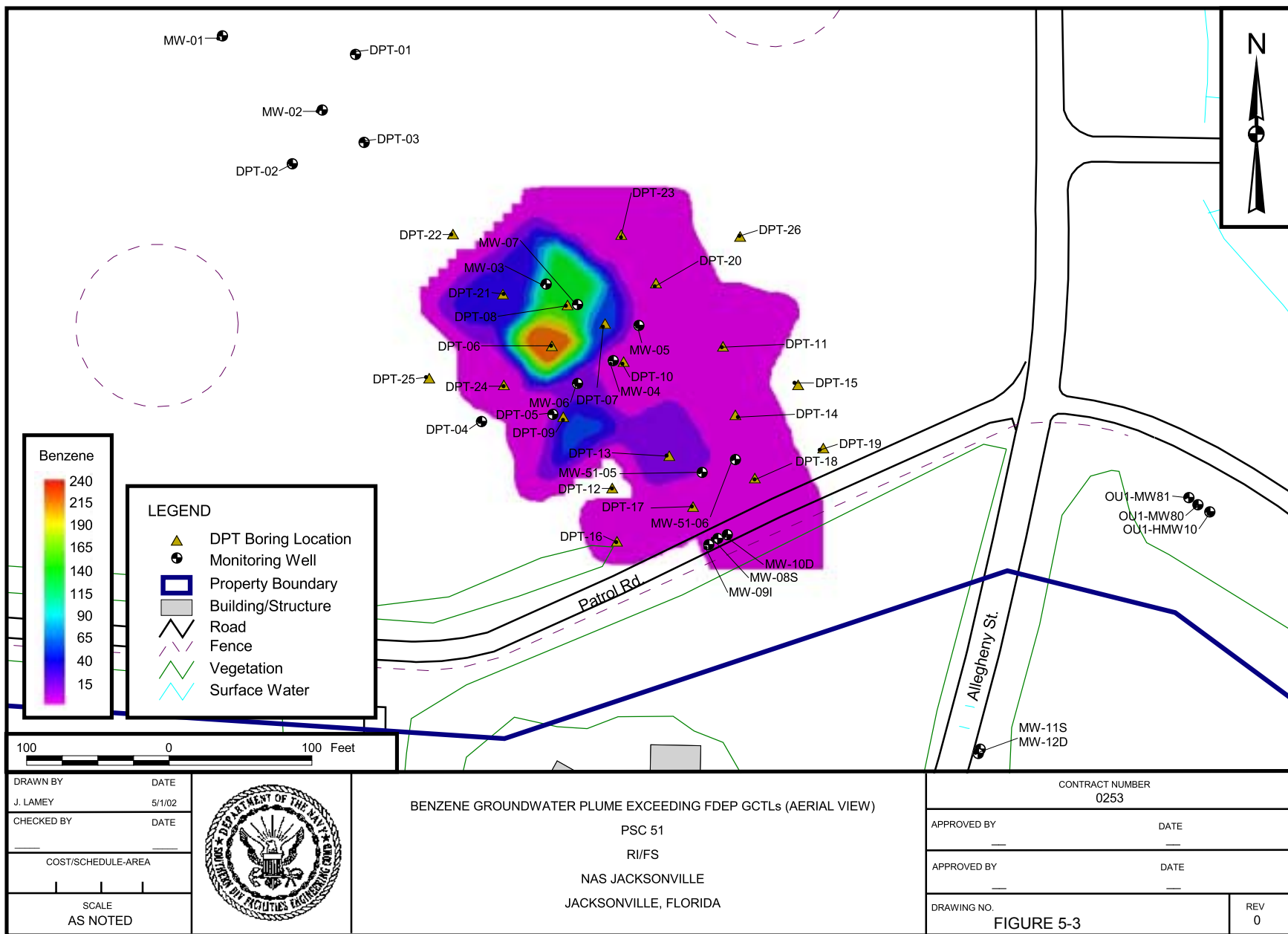
The vertical extent of these constituents has also been defined. The surficial aquifer at PSC 51 terminates on top of an extensive limestone and clay unit, which prevents continued vertical migration of these constituents.

The distribution of VOC data is consistent with the USGS model for groundwater flow at PSC 51 (see Appendix A). In the vicinity of the ODA, groundwater flow is characterized by a southeasterly horizontal gradient. Near the creek, a vertical upward vertical gradient exists. This upward gradient and the northerly flow condition measured in the neighborhood south of PSC 51, indicate that the un-named creek

TINUS-FY00-0086

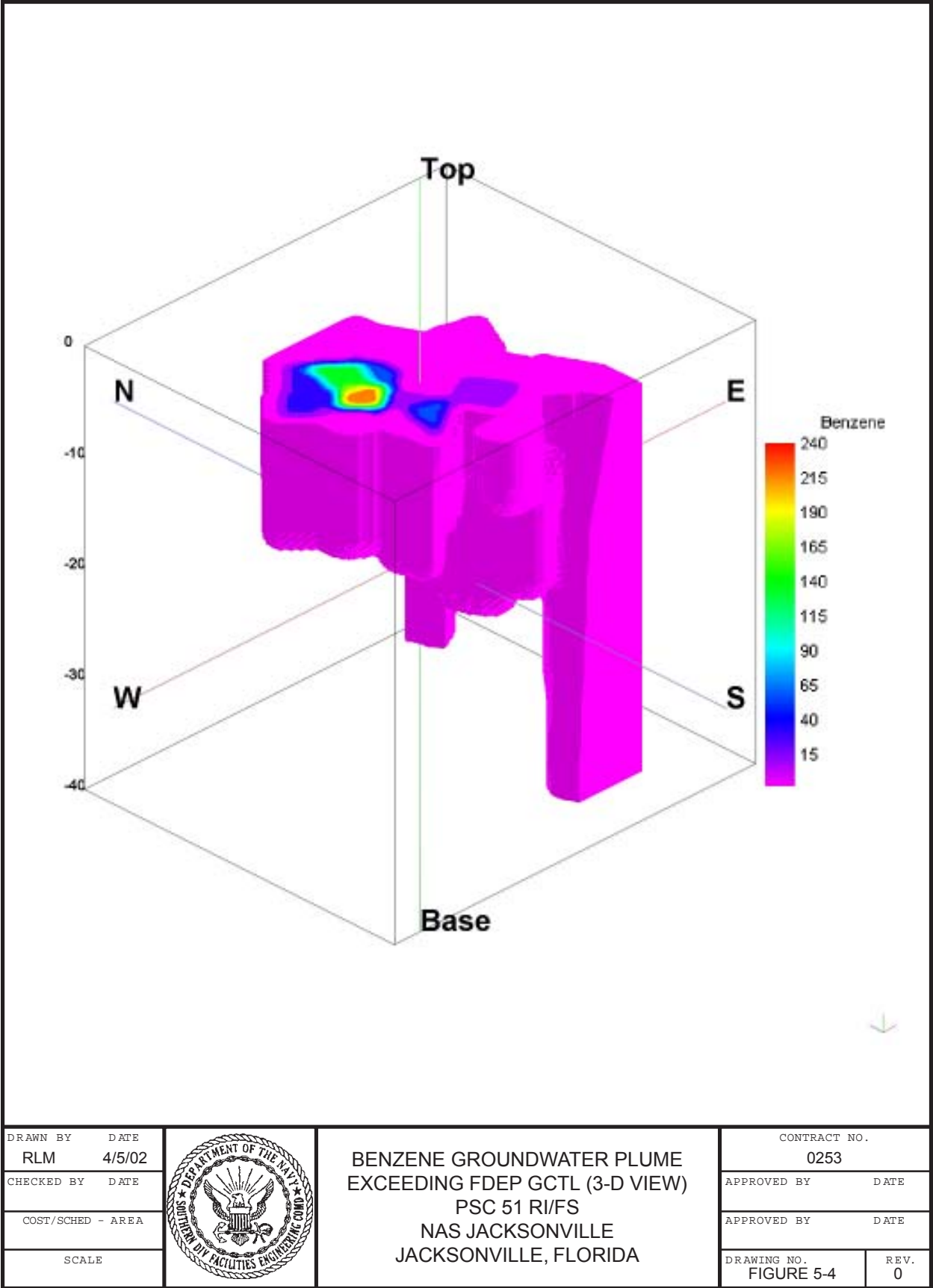
5-41

CTO 0100



P:\GIS\JACKSONVILLE_NAS\APR\PSC_51.APR BENZENE GROUNDWATER PLUME 5/1/02 JAL

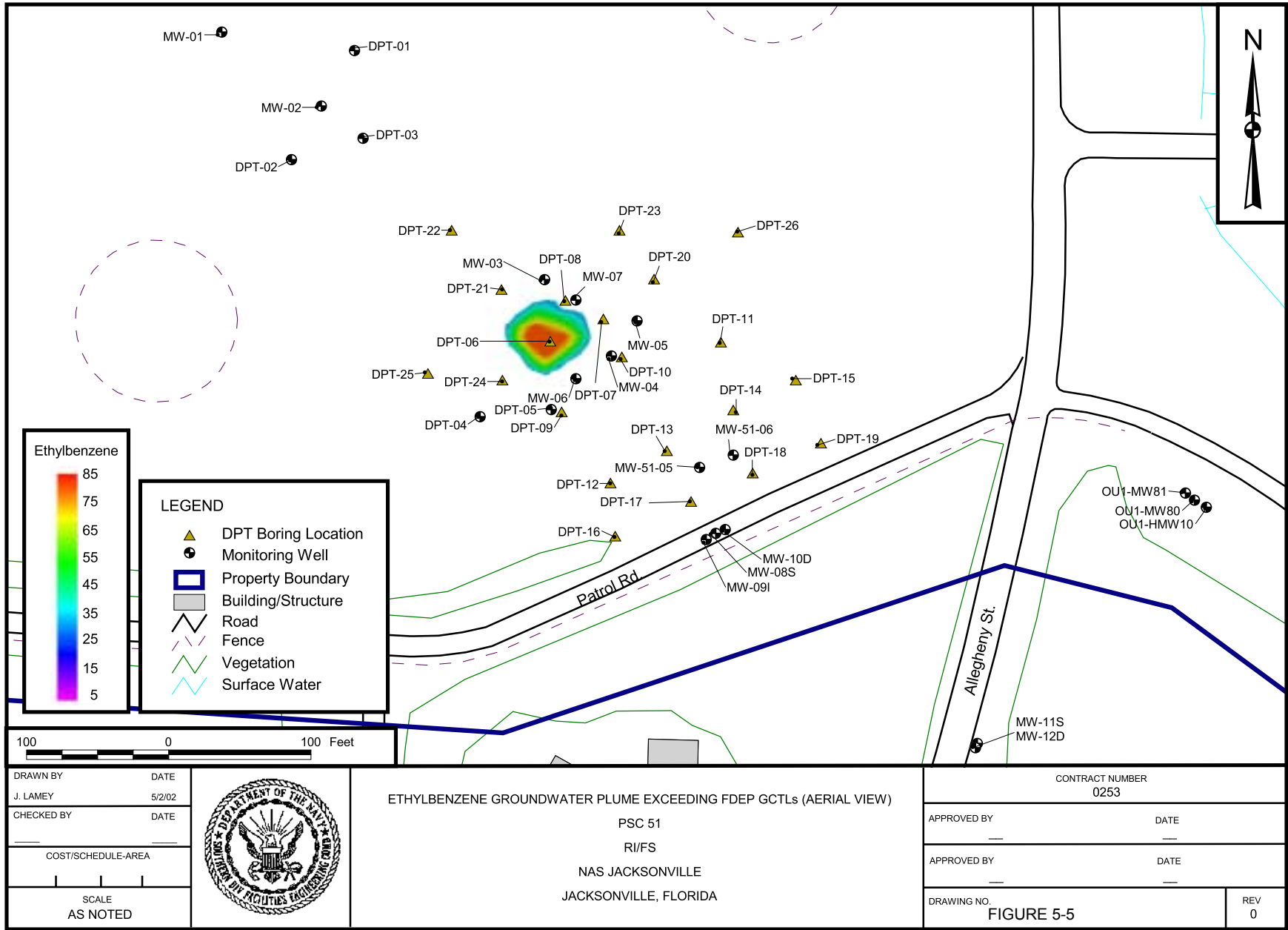
Rev. 2
09/06/02



TINUS-FY00-0086

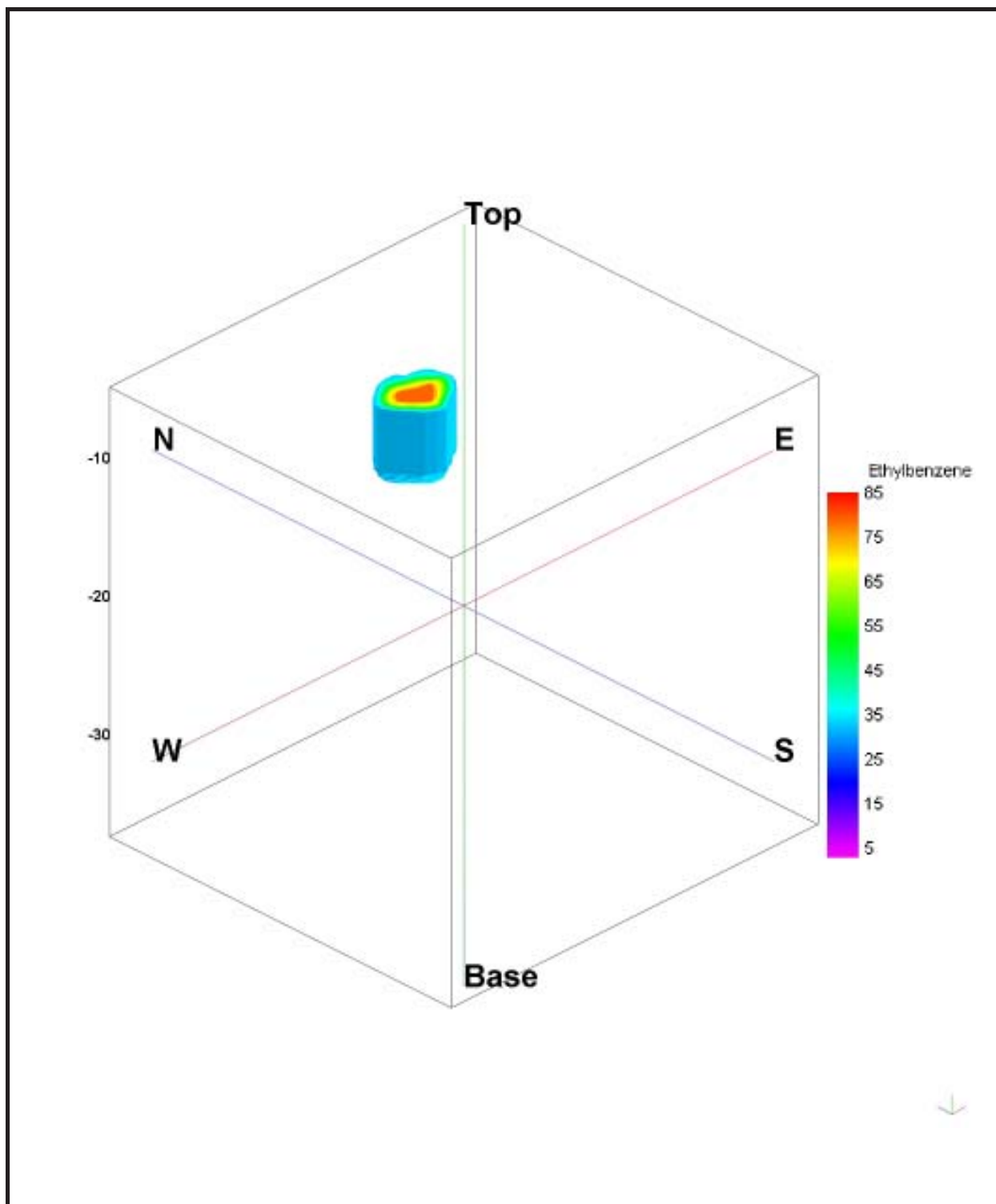
5-43


CTO 0100



P:\GIS\JACKSONVILLE_NAS\APR\PSC_51.APR ETHYLBENZENE GROUNDWATER PLUME 5/2/02 JAL

Rev. 2
09/06/02

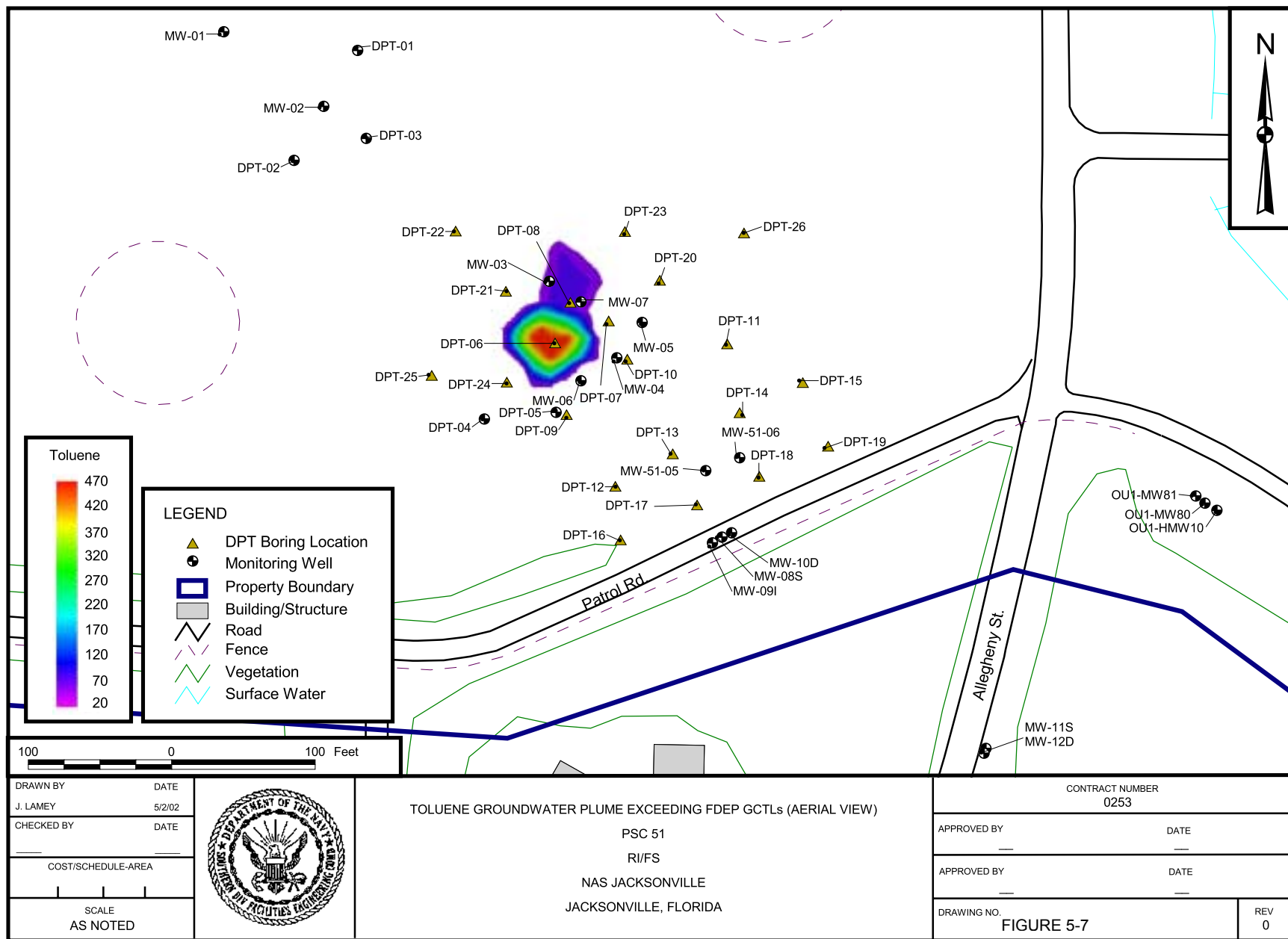


DRAWN BY RLM	DATE 4/5/02		ETHYLBENZENE GROUNDWATER PLUME EXCEEDING FDEP GCTL (3-D VIEW) PSC 51 RI/FS NAS JACKSONVILLE JACKSONVILLE, FLORIDA		CONTRACT NO. 0253	
CHECKED BY	DATE		APPROVED BY	DATE		
COST/SCHED - AREA			APPROVED BY	DATE		
SCALE			DRAWING NO. FIGURE 5-6	REV. 0		

TINUS-FY00-0086

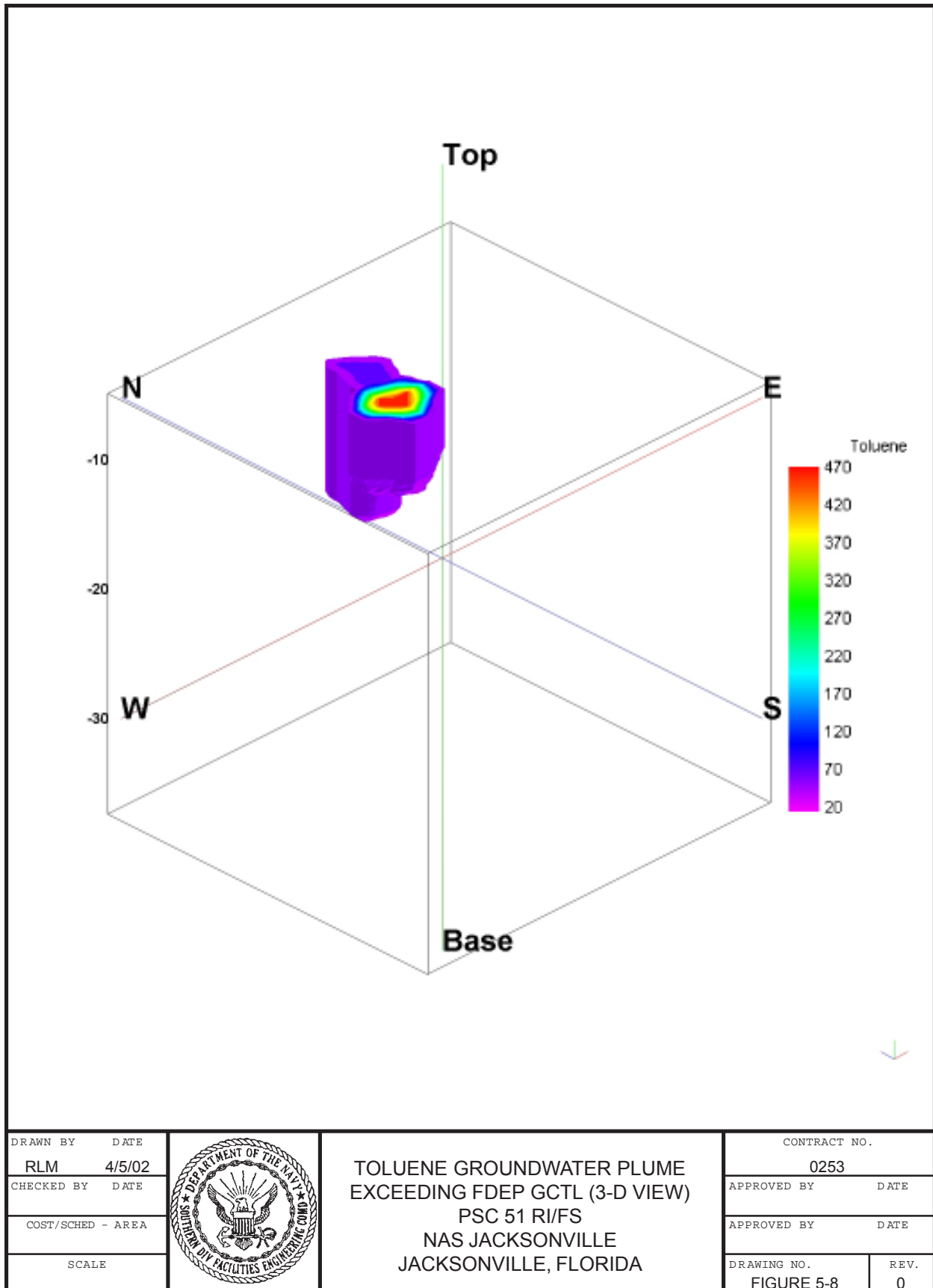
5-45

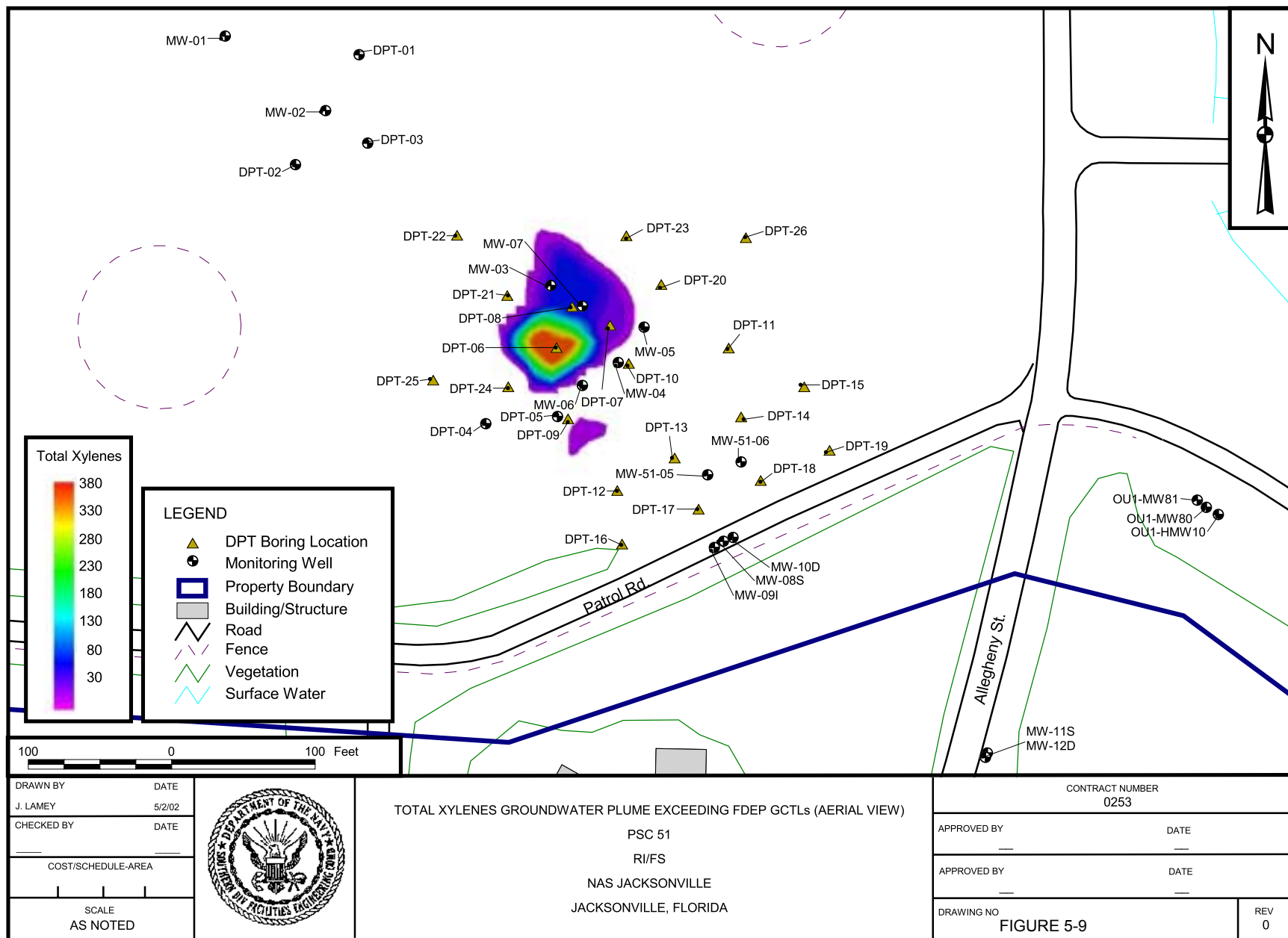
CTO 0100



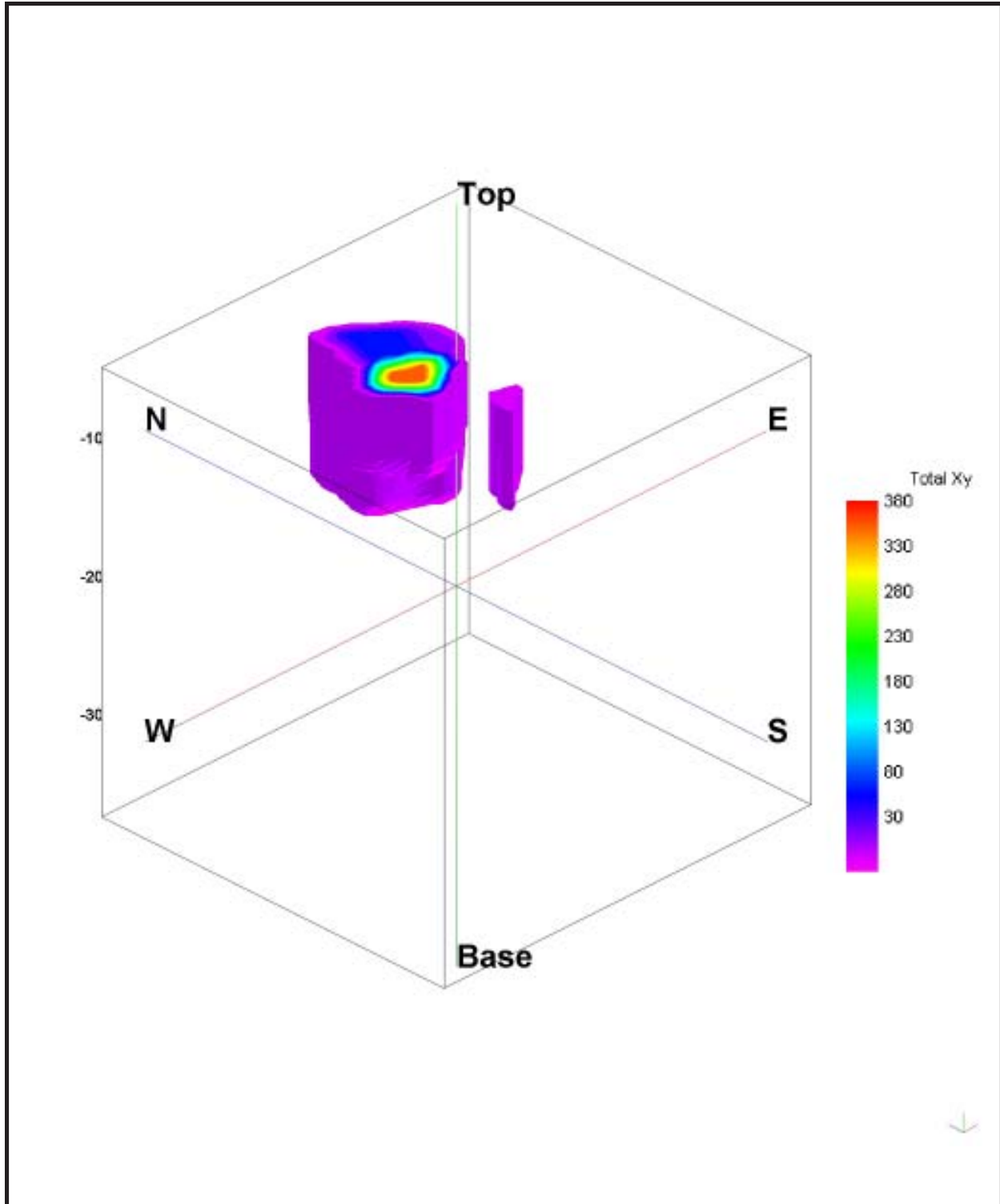
P:\GIS\JACKSONVILLE_NAS\APR\PSC_51.APR TOLUENE GROUNDWATER PLUME 5/2/02 JAL


Rev. 2
09/06/02

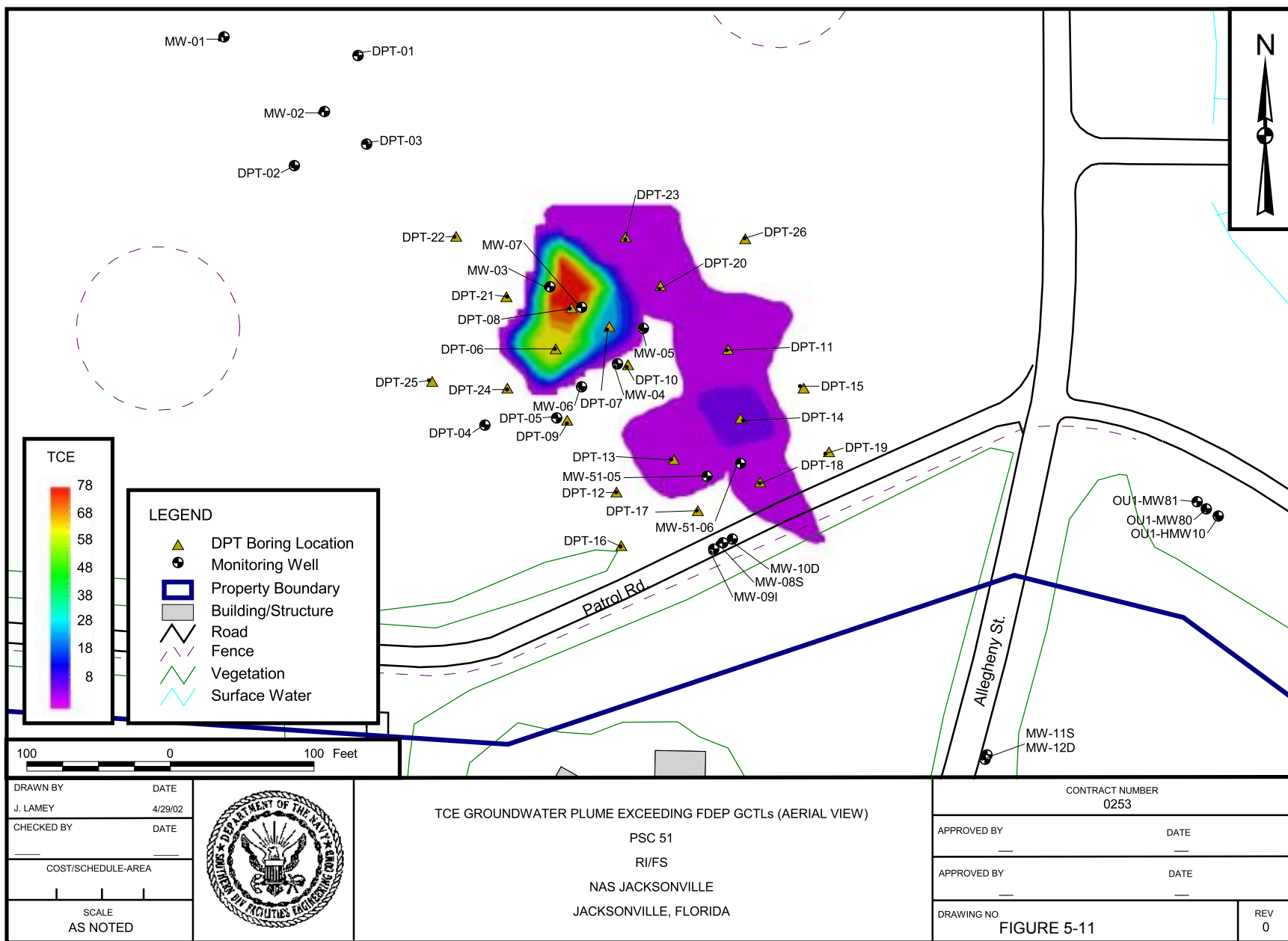




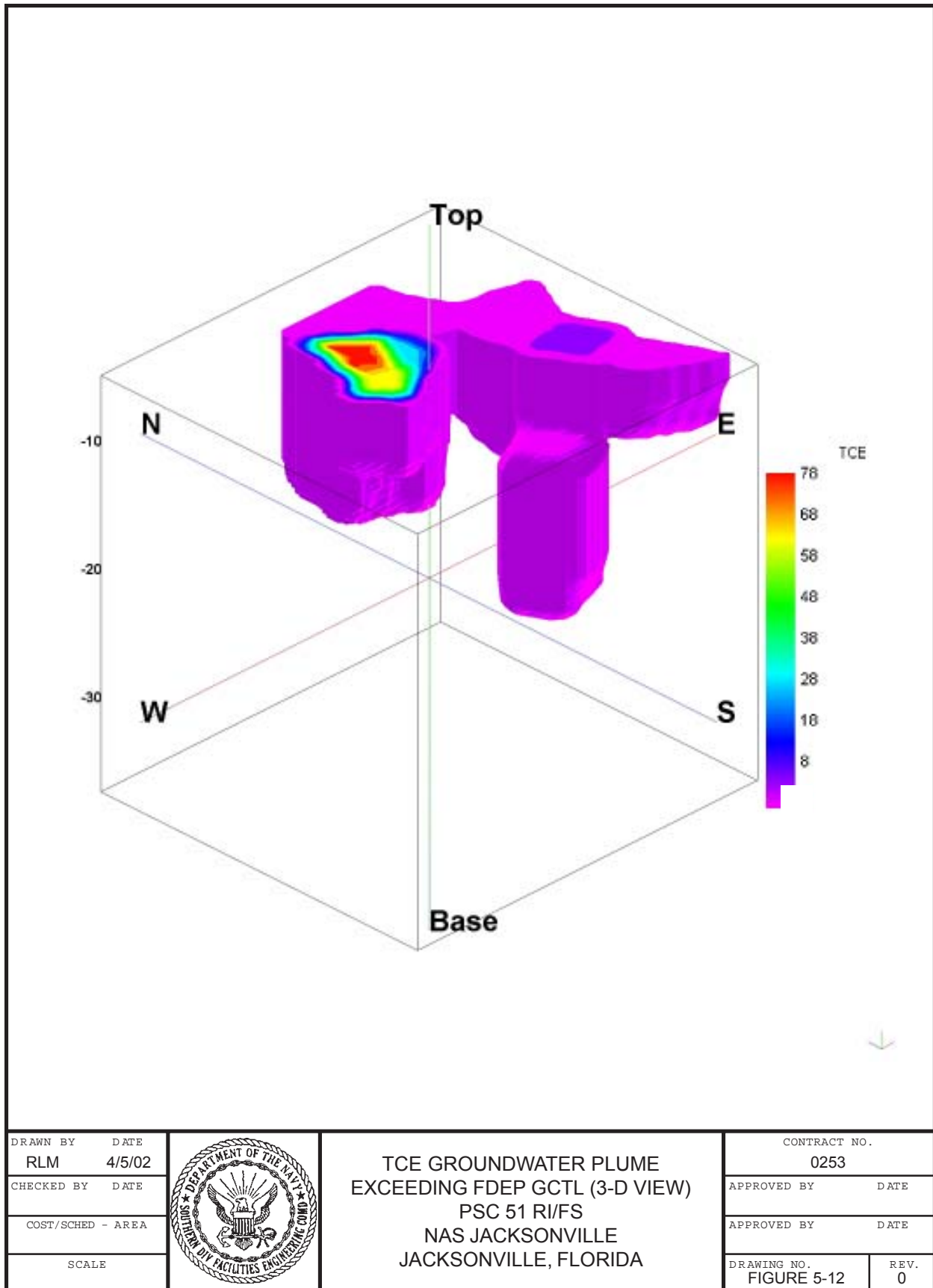
P:\GIS\JACKSONVILLE_NAS\APR\PSC_51.APR TOTAL XYLENES GROUNDWATER PLUME 5/2/02 JAL



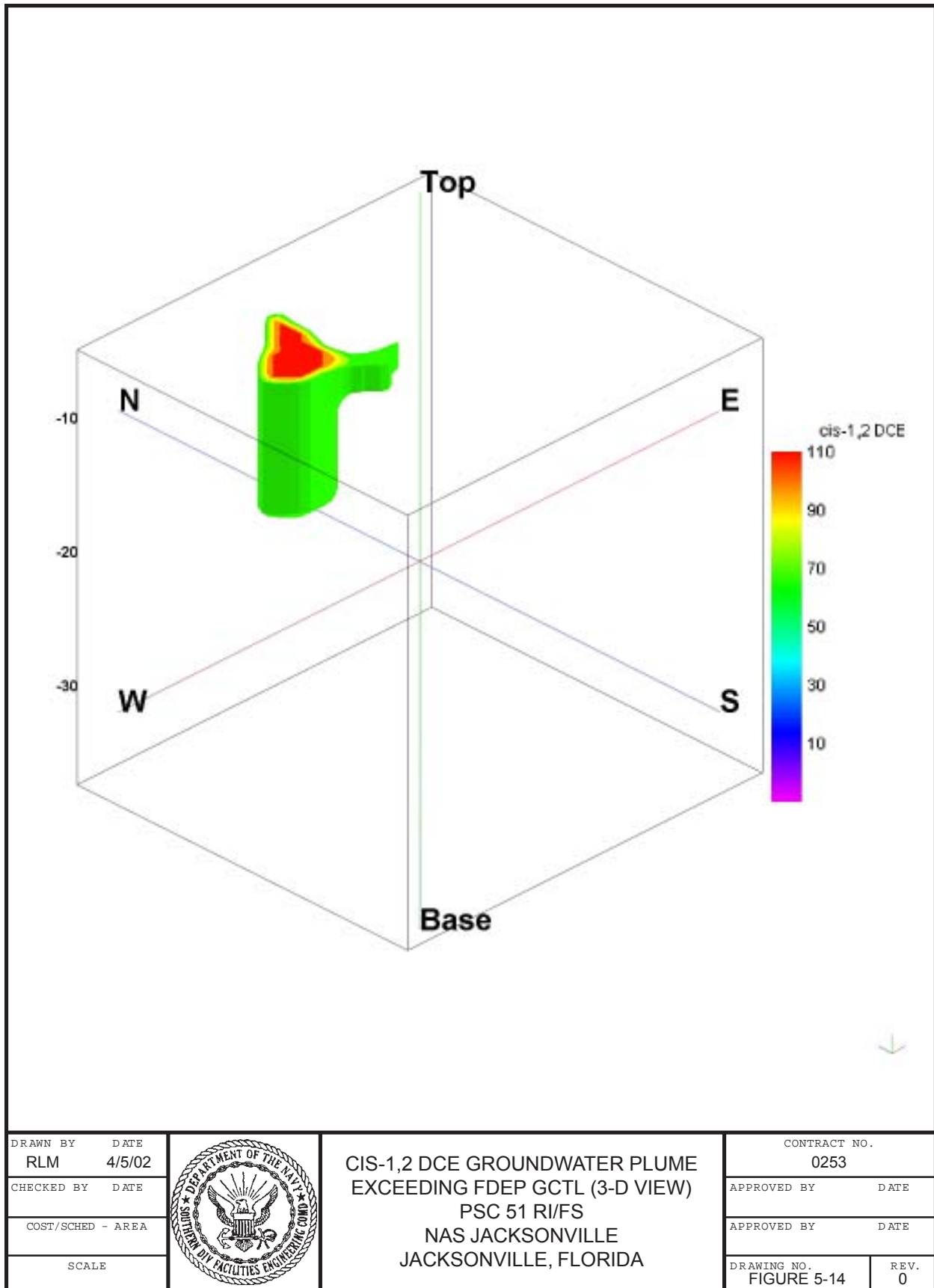
DRAWN BY	DATE		CONTRACT NO.	
RLM	4/5/02		0253	
CHECKED BY	DATE		APPROVED BY	DATE
COST/SCHED - AREA			APPROVED BY	DATE
SCALE			DRAWING NO.	REV.
			FIGURE 5-10	0
TOTAL XYLENES GROUNDWATER PLUME EXCEEDING FDEP GCTL (3-D VIEW) PSC 51 RI/FS NAS JACKSONVILLE JACKSONVILLE, FLORIDA				

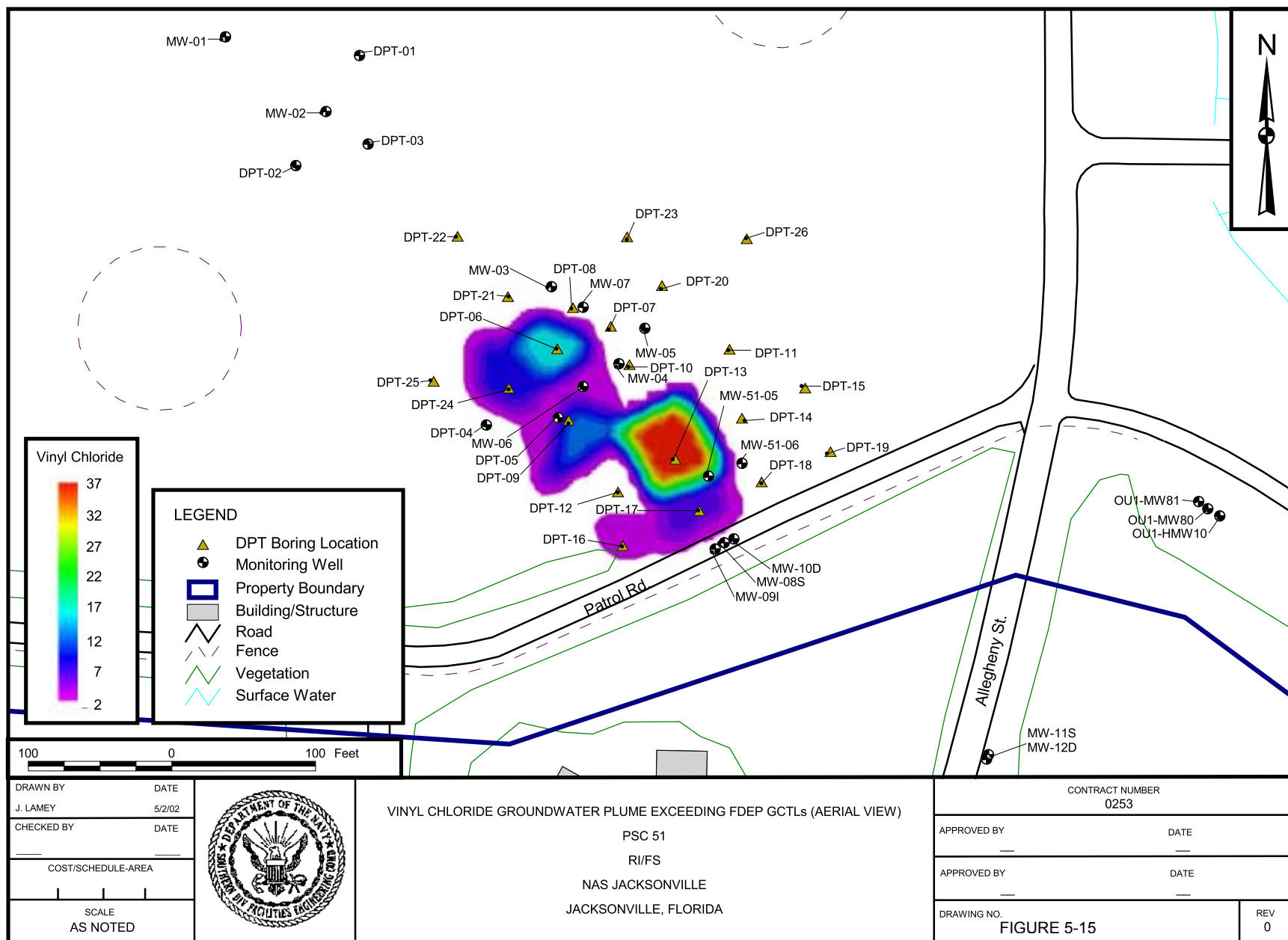


P:\GIS\JACKSONVILLE_NAS\APR\PSC_51.APR TCE GROUNDWATER PLUME 5/1/02 JAL

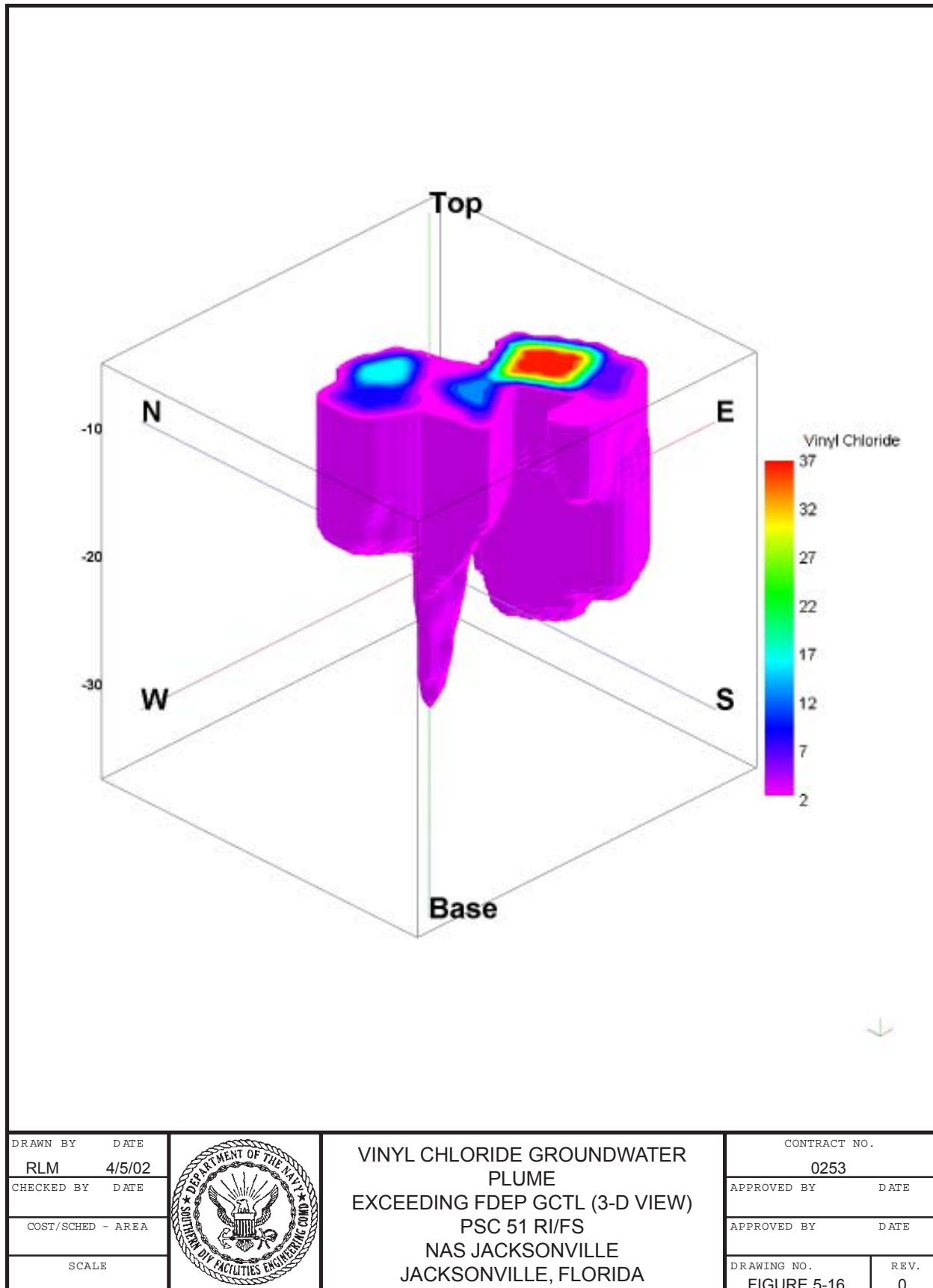








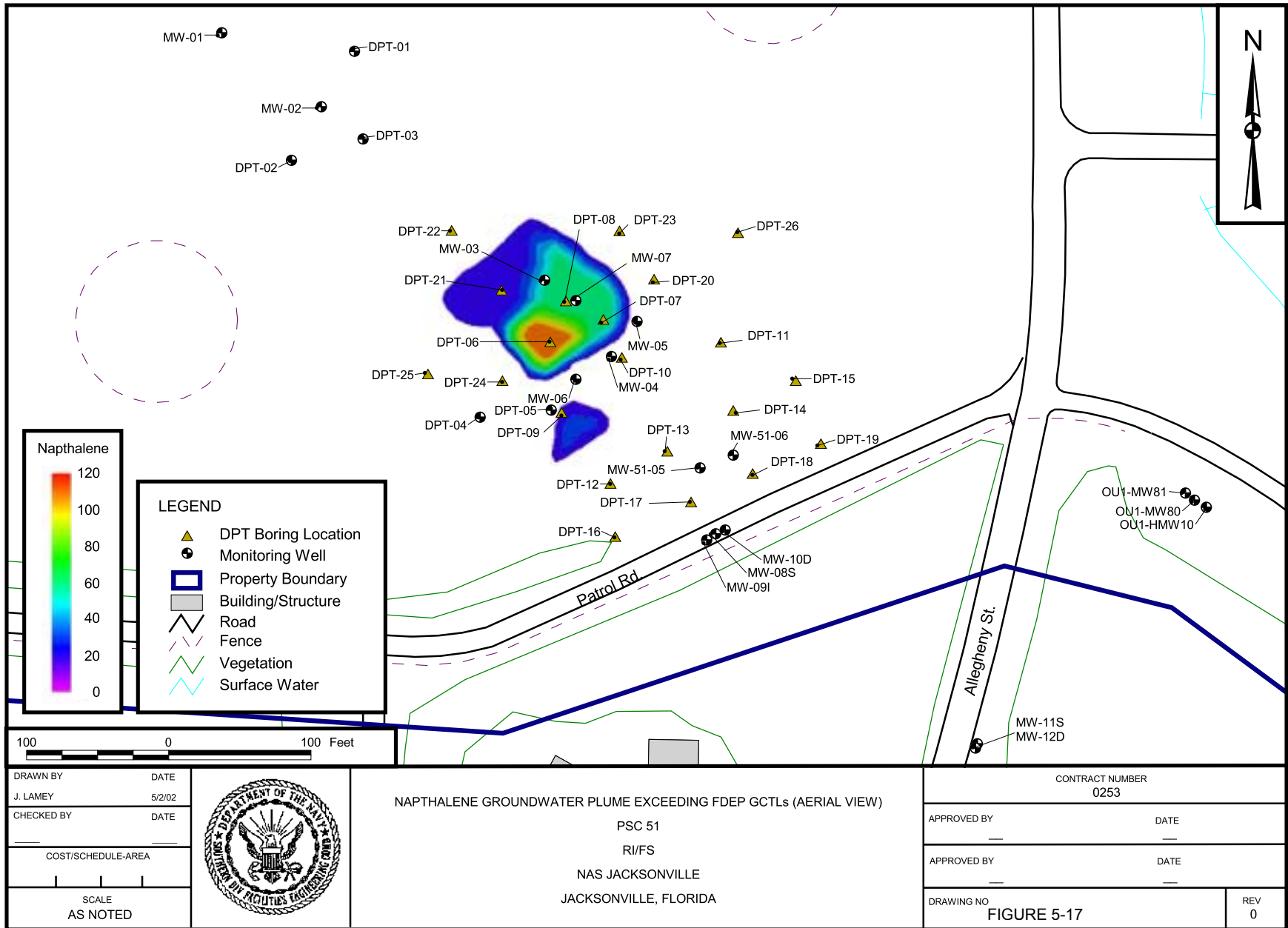
P:\GIS\JACKSONVILLE_NAS\APR\PSC_51.APR VINYL CHLORIDE GROUNDWATER PLUME 5/2/02 JAL



TTNUS-FY00-0086

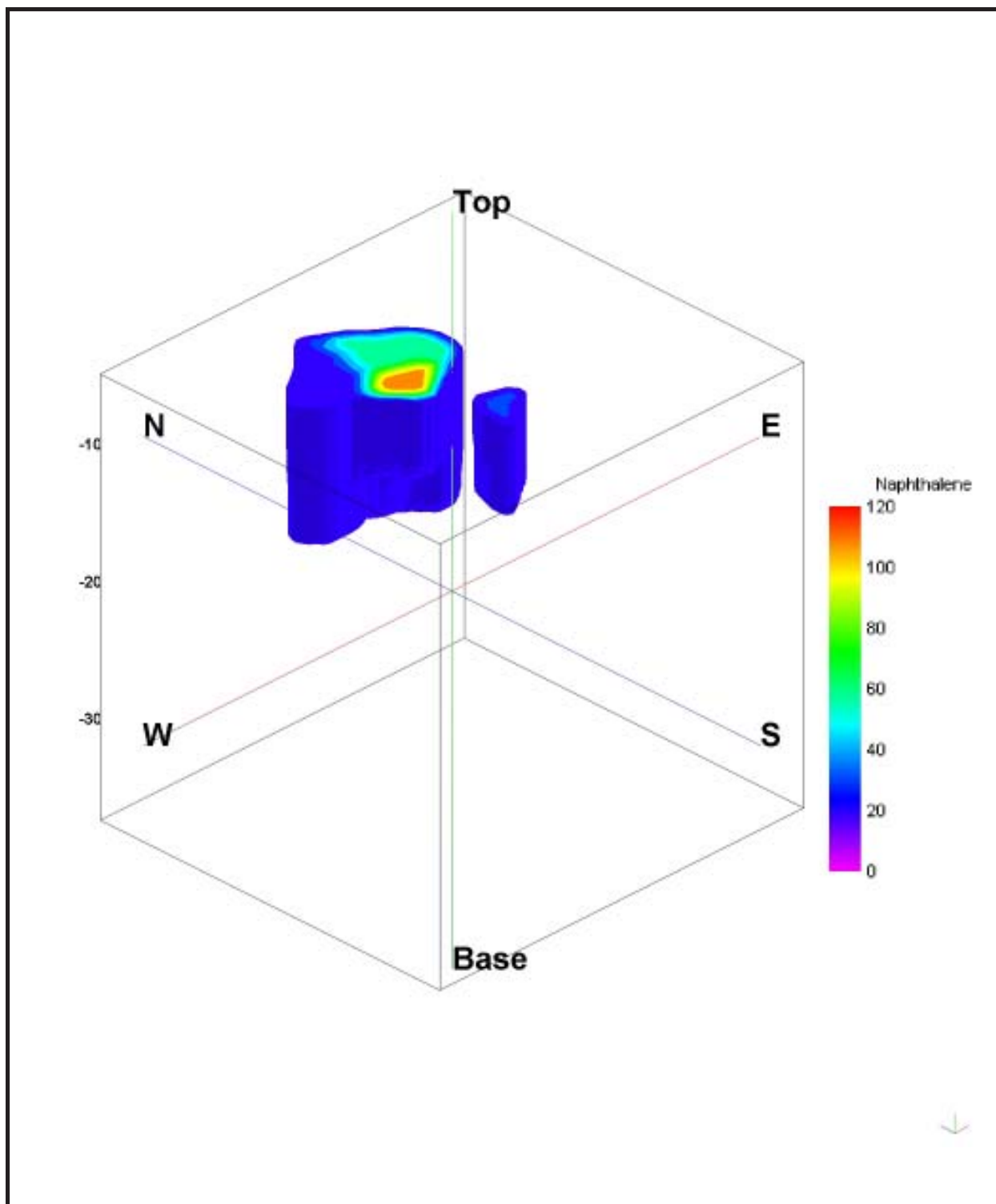
5-55


CTO 0100



P:\GIS\JACKSONVILLE_NAS\APR\PSC_51.APR NAPHTHALENE GROUNDWATER PLUME 5/2/02 JAL

Rev. 2
09/06/02



DRAWN BY RLM	DATE 4/5/02		CONTRACT NO. 0253	
CHECKED BY	DATE		APPROVED BY	DATE
COST/SCHED - AREA			APPROVED BY	DATE
SCALE			DRAWING NO. FIGURE 5-18	REV. 0

NAPHTHALENE GROUNDWATER PLUME
EXCEEDING FDEP GCTL (3-D VIEW)
PSC 51 RI/FS
NAS JACKSONVILLE
JACKSONVILLE, FLORIDA

is the primary receptor for groundwater from the ODA. Monitoring of surface water indicated that VOCs in groundwater are not currently degrading the surface water quality in the unnamed creek.

SVOCs

Two SVOCs (naphthalene and 2-methylnaphthalene) were detected at concentrations exceeding GCTLs. Both were detected in MW-04 only and had a concentration increase between the 1997 and 1999 sampling events. The increases, however, were slight and may represent other factors such as variations in sample collection and analytical procedures.

PAHs

The only PAH that exceeded GCTLs was naphthalene in the groundwater sample from MW-04 (30 µg/L). The concentration reported is similar to the concentration detected using the SVOC analytical method and further confirms that naphthalene is present in MW-04 in excess of GCTLs. None of the other PAH compound concentrations exceeded GCTLs in the 14 groundwater samples analyzed.

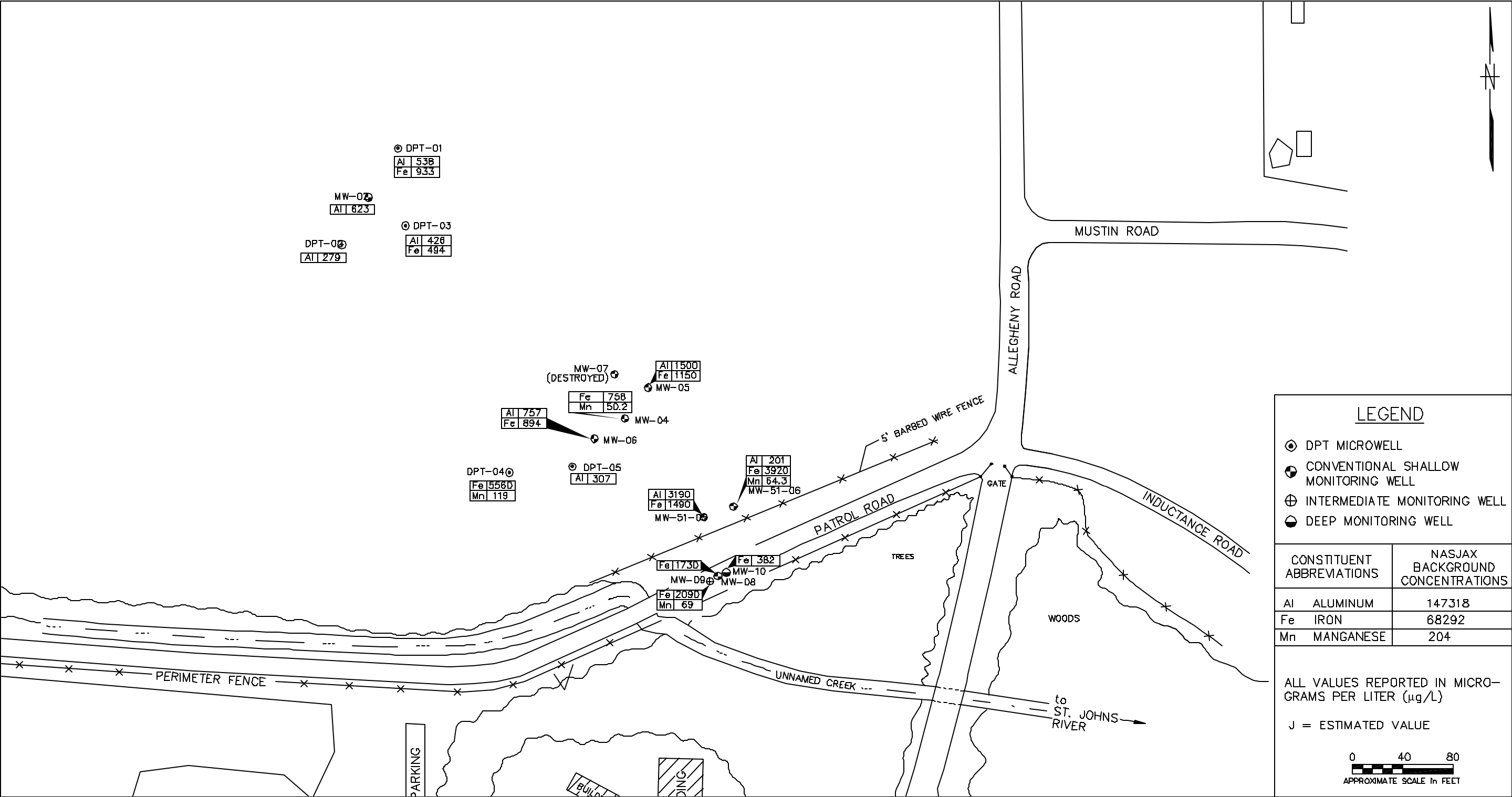
Inorganic Compounds (TAL Metals)

Fourteen inorganic compounds were detected in the 14 groundwater samples analyzed. Three inorganic constituents (aluminum, iron, and manganese) were detected in excess of FDEP GCTLs (See Figure 5-19), and three other metals (calcium, magnesium, and potassium) did not have established FDEP GCTLs or USEPA MCLs. Of those that have established criteria, eight were detected at concentrations below GCTL or MCL values. These include barium, cadmium, chromium, copper, lead, nickel, vanadium, and zinc. The constituents without GCTLs and with detected concentrations above GCTLs are discussed further.

Those constituents without GCTL or MCL values include calcium, magnesium, and potassium. Of these constituents, only calcium was detected in concentrations above background levels. The range of calcium concentrations varied from 980 to 112,000 µg/L with a station-wide background level of 59,066 µg/L. Although some calcium concentrations exceeded background values, the concentrations were not unusual for the North Florida region as Fairchild (1972) has reported calcium concentrations ranging from 200 to 596,000 µg/L.

Aluminum was detected in 11 of the groundwater samples analyzed at concentrations ranging from 109 µg/L to 3,190 µg/L. The concentrations in the groundwater samples from MW-02, MW-05, MW-06,

S:\NAVY\SITES\CTO 100\CAD\0253G04



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		INORGANIC CONSTITUENT CONCENTRATIONS EXCEEDING FDEP GCTLs IN GROUNDWATER SAMPLES PSC 51 NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. 0253	
											APPROVED BY	DATE
											APPROVED BY	DATE
											DRAWING NO. FIGURE 5-19	REV. 0

DPT-01, DPT-02, DPT-03, DPT-05, MW-51-05, and MW-51-06 exceeded the FDEP GCTL of 200 µg/L. None of these detections exceeded the NAS Jacksonville basewide background concentration of 147,659 µg/L established in the OU 1 RI/FS document (ABB-ES, 1996). Since there were no reported aluminum wastes released in this area, it appears that the aluminum concentrations detected represent background concentrations.

Iron was detected in all of the groundwater samples analyzed at concentrations ranging from 154 µg/L to 5,560 µg/L. The concentrations in the groundwater samples from all except MW-02, DPT-02, and DPT-05 exceeded the FDEP GCTL of 300 µg/L. None of the detections exceeded the NAS Jacksonville basewide background concentration of 68,292 µg/L. Therefore, these detections are assumed to represent naturally occurring conditions.

Manganese was detected in 11 of the 14 groundwater samples analyzed at concentrations ranging from an estimated concentration of 14.3 µg/L to 119 µg/L. The concentrations in the groundwater samples from MW-04, MW-09, DPT-04, and MW-51-06 exceeded the FDEP GCTL of 50 µg/L. None of these detections exceeded the NAS Jacksonville basewide background concentration of 204 µg/L. From this, it appears that these concentrations represent background.

Although arsenic exceeded residential and leaching criteria in the surface soils, it was not detected in any of the groundwater samples. None of the other TAL metals constituents were detected in excess of the GCTLs.

5.3.4.3 Additional Groundwater Assessment Results

As discussed in Section 4.0, after the completion of the initial RI activities and the submittal of the draft RI/FS, the Partnering Team agreed that additional horizontal and vertical delineation of the VOC plume was necessary. Consequently, TtNUS performed additional RI field activities in September 2001 to accurately characterize the extent of VOC contamination. To complete the delineation, borings were installed using DPT and groundwater samples were collected and analyzed by the mobile laboratory. The mobile laboratory analyzed groundwater samples for the previously detected constituents, benzene, toluene, ethylbenzene, xylenes, TCE, 1,2-DCE (cis and trans), vinyl chloride, and naphthalene. Field duplicate samples were collected from 10 percent of the samples submitted to the fixed-based laboratory for analytical verification. The analytical results are provided below. TtNUS' interpretation is also included below.

VOCs

Toluene was detected in seven samples ranging in concentration from 1.0 µg/L to 470 µg/L. The highest concentration was detected in boring DPT-6-10' (470 µg/L). Toluene was detected in two samples in excess of the GCTL (40 µg/L). Toluene was detected to a depth of 10 ft bls.

Ethylbenzene was detected in eight samples ranging in concentration from 1.7 µg/L to 85 µg/L. The highest concentration was detected in boring DPT-6-10' (85 µg/L). Ethylbenzene was detected in one sample in excess of the GCTL (30 µg/L). Ethylbenzene was detected to a depth of 10 ft bls.

Total xylenes was detected in nine of the 80 groundwater samples ranging in concentration from 1.8 µg/L to 380 µg/L. The maximum detected concentration was reported for a sample collected from DPT-6-10'. Total xylenes was detected in four samples in excess of the GCTL (20 µg/L). Total xylenes were detected to a depth of 30 ft bls.

SVOCs

One SVOC (naphthalene) was analyzed during the additional RI activities. The mobile laboratory analyzed naphthalene by USEPA Method 8260 with a method detection limit of 1 µg/L. Naphthalene was detected in 22 groundwater samples ranging in concentration from 1.0 µg/L to 120 µg/L. The maximum concentration was reported for a sample collected from DPT-6-10'. Naphthalene was detected in five samples in excess of the GCTL (20 µg/L). Naphthalene was detected to a depth of 40 ft bls.

5.3.4.4 Interpretation of Additional Groundwater Data

The interpretation is presented below.

VOCs

Of the constituents analyzed, all eight were detected in at least one well (not necessarily the same well). Seven of the eight VOCs (benzene, ethylbenzene, toluene, total xylenes, TCE, cis-1,2-DCE, and vinyl chloride) exceeded their respective FDEP GCTLs. These constituents were detected in the samples collected from DPT borings and monitoring wells located from the FFTA to the unnamed creek. To assure the accuracy of the mobile laboratory results field replicate sampling was performed on 10 percent of the samples submitted to the mobile laboratory. Seven replicate samples were submitted to the fixed-based laboratory from groundwater samples collected from both monitoring wells and DPT points. The results from the fixed-based laboratory were validated and then compared to the mobile laboratory analytical

results. For comparing aqueous analytical results a relative percent difference calculation was used. Typically, a difference greater than 30 percent may indicate inaccuracy. Results of the comparison indicate an average relative percent difference of 17 percent. The maximum difference was from the sample collected from MW-05, with a mobile laboratory result for TCE of 2.8 µg/L and fixed-based laboratory result of 4 µg/L. The relative difference was 35 percent. A comparison of all other constituents indicated a relative difference of less than 30 percent. The comparison indicates the mobile laboratory results are within the necessary range of accuracy for the investigative purpose.

The benzene concentrations are highest near the previous ODA and are significantly lower in wells in the vicinity of the unnamed creek. This is consistent with the results of prior investigations and the historical documentation. Groundwater to the southeast has transported the benzene contamination to the southeast. The detections appear to form a definitive plume, with concentrations decreasing downgradient and near the lateral boundaries. Figures 5-3 and 5-4 illustrate the benzene groundwater plume to Florida GCTLs. The figures were generated using the modeling software program Rockworks™. Figure 5-3 is an aerial view and Figure 5-4 is a 3-dimension image.

Benzene was detected in monitoring well MW-10 (screened from approximately 45.5 to 50.5 ft bls), suggesting that benzene has migrated vertically within the shallow aquifer. However, benzene was not detected below 20 ft bls during the DPT screening, and was not detected on the opposite side of the unnamed creek in monitoring wells MW-13S and MW-14D.

TCE concentrations are highest near the ODA. The TCE isocontour from the September 2001 sampling event (see Figure 5-11 and 5-12) shows that TCE is migrating in the direction of the groundwater movement. The modeling results indicate TCE migrating beyond the downgradient well nest and towards the unnamed creek. TCE was detected to a depth of 20 ft bls in the southern portion of the plume indicating limited vertical plume migration as plume moves to the southeast. TCE was not detected in the deep monitoring well MW-10D.

Cis-1,2-DCE was detected at two sampling points (DPT-06 and DPT-21) in excess of the Florida GCTL. As indicated by Figures 5-13 and 5-14, the cis-1,2-DCE concentrations above the GCTL are located in the ODA, west of the area excavated by BEI. Cis-1,2,-DCE was detected in the downgradient monitoring wells MW-08S and MW-10D at concentrations below the GCTL, indicating contaminant migration towards the unnamed creek.

The vinyl chloride plume is presented on Figures 5-15 and 5-16. As indicated on the figures the vinyl chloride concentration increases toward the downgradient area of the plume. Vinyl chloride was detected to a depth of 20 ft bls.

The ethylbenzene (Figures 5-5 and 5-6), toluene (Figures 5-7 and 5-8), and total xylene (Figures 5-9 and 5-10) plumes indicate concentrations of constituents above GCTLs located in the ODA west of the BEI excavation. The analytical results and figures indicate elevated concentrations in the former source area and limited horizontal migration. Toluene and xylenes were detected to a depth of 30 ft bls and the sampling location DPT-16 indicating vertical migration. The concentrations of xylenes and toluene at DPT-16 were below FDEP GCTLs. Ethylbenzene was not detected above the method detection limit from samples collected below 10 ft bls.

SVOCs

Naphthalene was detected at 22 sampling locations during the additional RI activities. The naphthalene concentrations are highest in the ODA west of the former BEI soil excavation. The modeling results (presented in Figures 5-17 and 5-18) indicate concentrations of naphthalene in excess of the GCTL are primarily located in the former ODA and in an area to the south-southeast. Naphthalene was detected to a depth of 39 ft bls from sampling point DPT-9.

Summary

The total contaminant plume at PSC 51 incorporates an area starting near well DPT-02 to an area downgradient of the well nest MW-08, MW-09I, and MW10D. The plume is an elliptical shape with the leading edge to the southeast in the same direction as the groundwater flow path. The largest plume footprints are the benzene and vinyl chloride plumes. Except for benzene, the other constituents were not detected above their respective GCTLs at depths below 20 ft bls. Benzene was detected above the GCTL in the deep downgradient monitoring well MW-10D. However, no contaminants were detected in monitoring wells MW-13S and MW-14D located on the opposite side of the unnamed creek. Additionally, as discussed in Section 2.0, the groundwater in the shallow and deep zones discharges to the unnamed creek from both the north and the south. Thus indicating an endpoint for contaminant plume movement.

6.0 CONTAMINANT FATE AND TRANSPORT

This chapter discusses the fate and transport of contaminants detected in the environment at PSC 51. Fate, in the context of this chapter, refers to the ultimate disposition of a given contaminant following its release into the environment. Transport refers to the mechanism(s) by which a given contaminant released into the environment will arrive at its fate. Explanation of the fate and transport of organic compounds and metals in the environment can be very complicated, depending on the physical, chemical, and biological characteristics of the compound or metal considered and the environment into which that compound is released. Some compounds volatilize into the atmosphere and are diluted beyond detection; other compounds attach to organic material in the soil and remain there without degradation or further transport attenuation.

Organic compounds and metals were detected in samples from the four media sampled at PSC 51 (surface soil, sediment, surface water, and groundwater) during this RI. Because of the number of potential contaminants detected and the myriad fate and transport scenarios possible for those contaminants in the four media, this discussion will focus only on those compounds and metals that may pose significant risk to human health and environment, as identified by the risk assessment. These chemicals and the media that was identified with potential health risks are arsenic in surface soil, and benzene, 1,1-DCE, and vinyl chloride in groundwater. The HHRA completed for PSC 51 is presented in Section 7.0 and the ERA is included in Section 8.0 of this document.

The following discussion of contaminant fate and transport is divided into three sections. Section 6.1 discusses potential routes of contaminant migration in the media evaluated and does not focus specifically on media found to be of concern at PSC 51. The site-specific persistence, fate, and transport of those compounds and elements found to pose a potential risk to human health or the environment are discussed in Sections 6.2. A NA evaluation for the organic constituents in groundwater is presented in Section 6.3.

6.1 POTENTIAL ROUTES OF MIGRATION

Several routes of migration are possible for a contaminant in the various media are air, soil, surface water, groundwater, and biota. These routes are summarized below.

Air Gases and particulate material can be transported in the atmosphere. Organic compounds, metals, and metal complexes that exist as gases at surface temperature and pressure may become entrained in air and thereby migrate. The extent to which gaseous constituents and particulate material remain airborne is a function of their density, the level of excitation of the air (wind and temperature), and

fate processes acting on the constituent. Particulate material may contain (or consist of) organic compounds and elements that would otherwise not be present in a gaseous medium having the atmosphere's composition.

Soil Organic compounds and metals can be present in soil. The primary agents of migration acting on soil include wind, rainwater, running water, biological activity, and human activity. Wind commonly transports soil in the form of particulate material. Rainwater may cause soil to migrate either by washing soil particles downward into the subsurface or by carrying soil particles overland to surface water bodies or other areas of deposition. The amount and type of vegetative cover and surface disturbance by human's affects the degree to which wind and water cause soil to migrate.

Surface Water Organic compounds and elements can migrate in surface water. The primary mechanism for migration of constituents in surface water is dissolution and suspension. Several organic compounds and metals are soluble in water and will remain in the aqueous phase until fate mechanisms cause removal or may be transported by surface water via suspension. The amount of suspended particulate material in surface water is largely a function of the water's energy and as that energy decreases, suspended material will settle and become part of the soil or sediment. Colloidal material may remain in suspension (by electrochemical forces) in water of very low energy (e.g., standing water).

Sediment Organic compounds and elements can exist in sediment (generally defined as detrital material under water). Saltation, biological action, human action, and other mass transport mechanisms (such as traction and suspension) are the primary routes of migration for sediment. The physical, chemical, and biological fate processes affecting a constituent will determine where and how migration from sediment will occur.

Groundwater Groundwater is a liquid medium capable of transporting constituents in a dissolved state. Organic compounds and elements generally reach groundwater either by being placed directly in the water table (e.g., disposal pits) or by being leached from soil or solid waste to the water table by physical or chemical processes. Groundwater may discharge to the land surface, surface water bodies, other aquifers, or pumping wells. The migration of constituents from groundwater upon discharge is a function of the fate process acting upon that individual constituent in the medium to which it is discharged.

Biota Biota may be considered a medium for migration of certain organic compounds and elements. Several compounds and elements are known to accumulate in the tissues of organisms (at various levels in the food chain). As these organisms are consumed by other organisms (higher in the food chain), compounds and elements are accumulated in their tissue and passed on to the higher organisms. In this manner, contaminants may be transported by biota. Additionally, some organisms disturb bed sediment

in streams and rivers. This disturbance can cause organic compounds and elements to be transported downstream as suspended material in surface water.

6.2 CONTAMINANT PERSISTENCE AND FATE

The discussion of contaminant persistence and fate in the environment is divided into two subsections. Subsection 6.2.1 discusses the processes that control the persistence and fate of organic compounds and elements in the environment. Subsection 6.2.2 discusses the primary persistence and fate characteristics as well as transport of the constituents detected at PSC 51.

6.2.1 Processes

The persistence and fate of chemical constituents in the environment depends on various chemical, physical, and biological processes. The predominant processes affecting the environmental persistence and fate of chemical constituents include solubility, photolysis, volatilization, hydrolysis, oxidation, chemical speciation, complexation, precipitation, and co-precipitation, cationic exchange, sorption, bioaccumulation, and biodegradation and bio transformation. These processes are briefly summarized below.

Solubility The solubility of chemical constituents in water is important in assessing their mobility in the environment. This is particularly important for the transport and ultimate fate of chemicals from soil and sediment to water (i.e., groundwater and/or surface water). Generally, for organic compounds, aqueous solubility is a function of molecular size, molecular polarity, hydrocarbon character, and the presence of other dissolved organic co-solvents. For metals and other inorganic parameters, solubility is generally controlled by chemical speciation, pH, oxidation-reduction potential (ORP) of groundwater (Eh), oxygen content, and the presence of dissolved and/or colloidal organic compounds [e.g., hydroxides and sulfates (USEPA, 1979)]. Increased solubility is usually directly related to increased environmental mobility, with groundwater and/or surface water being the principal transport medium. Therefore, solubility is a significant factor affecting a compound or element's fate in the water environment.

Photolysis Many chemical constituents, particularly organic compounds, are susceptible to photolytic degradation either directly or indirectly. Direct photolysis involves a splitting of the chemical compound by light, whereas indirect photolysis occurs when another compound is transformed by light into a reactive species (i.e., usually a hydroxyl radical) that reacts with and modifies the original compound. In general, photolysis primarily occurs within the atmosphere, although it may also occur to a limited extent in surface water and/or soil under certain environmental conditions (USEPA, 1979).

Volatilization Volatilization of organic chemicals from the water to the atmosphere is an important pathway for chemicals with high vapor pressures and low solubilities. For organic compounds, volatilization is a function of molecular size and is more likely to occur for compounds with low molecular weights.

Hydrolysis Hydrolysis involves the decomposition of a chemical compound by its reaction with water. The rate of reaction may be promoted by acid (hydronium ion, H_3O^+) and/or base (hydroxyl ion, OH^-) compounds. In general, most organic compounds are resistant to hydrolytic reactions unless they contain a functional group (or groups) capable of reacting with water. Metallic compounds, however, generally dissociate readily in water depending upon the aqueous environmental conditions (e.g., pH and ionic strength). For metals, hydrolytic dissociation is an indirect process that affects the primary fate and transport mechanisms of aqueous solubility.

Oxidation The direct oxidation of organic compounds in natural environmental matrices may occur but this is generally a slow, insignificant transformation mechanism of minimal importance (USEPA, 1979). However, some metallic compounds may be rapidly oxidized under naturally occurring environmental conditions when the surrounding environment changes from anaerobic to aerobic conditions.

Chemical Speciation Chemical speciation is important primarily for metals that may exist in multiple forms in the environment, particularly within aqueous matrices. In general, the aqueous speciation of metals depends primarily upon the relative stabilities of individual valence states (which are element specific), oxygen content, pH and Eh condition, and the presence of available complexing agents and/or other cations and anions (USEPA, 1979). Because various metallic species exhibit differential aqueous solubilities and differential mobilities within soil and/or sediment (USEPA, 1979), the particular speciation of an individual metal will greatly affect its environment mobility.

Complexation For metals, complexation with various ligands is an important process, because these complexes may be highly soluble in water. Complexation may, therefore, greatly enhance mobility within environmental matrices. Complexation depends upon numerous factors such as pH, Eh, type and concentration of complexing ligands, and other ions present (USEPA, 1979).

Most metals are capable of forming numerous organic and/or inorganic complexes in the natural environment (USEPA, 1979). Metals may form organo-metallic complexes, especially with naturally occurring organic acids (i.e., humic and fulvic acids). In some cases, these metallic species may exhibit varying affinities for different organic ligand (i.e., mercury and arsenic for amino acids and their derivatives) (USEPA, 1979). However, organo-metallic complex formation is usually favored over metallo-inorganic complexes.

Precipitation and Co-precipitation Both chemical precipitation and co-precipitation are important removal mechanisms, particularly for metals and metallo-cyanides from groundwater and/or surface water can greatly affect a metal's environmental mobility and, hence, its ultimate fate and transport.

Cationic Exchange Cationic exchange is important primarily for metals and other ions that may substitute with other cations of similar charge and size within the lattice structure of clay minerals in soil and/or sediment (USEPA, 1979). This process, therefore, can significantly affect the mobility of an aqueous metal cation by removing it from solution under certain environmental conditions.

Sorption The sorption of chemical constituents by inorganic particulate matter (i.e., soil or sediment) and organic compounds is an important process that affects mobility in environmental matrices. This process is particularly important for the fate and transport of chemicals from soil or sediment to water (i.e., groundwater and surface water). In general, most metals exhibit a potential for adsorption to inorganic particulate matter and organic compounds (USEPA, 1979). Organic compounds also exhibit sorptive capability, but show greater variability in their ability to sorb to particulate or organic matter. The tendency for organic compounds to sorb to soil or sediment is reflected in their organic carbon partition coefficient (K_{oc}). K_{oc} is a measure of relative absorption potential that is chemical specific and is largely dependent on the organic content of the soil. The normal range of K_{oc} values is from 1 to 10^7 with higher values indicating greater sorption potential. Sorption is generally considered high for K_{oc} ranging from 10^5 to 10^6 , moderate for K_{oc} of approximately 10^3 , and weak for K_{oc} of less than 150.

Regardless of chemical class, sorption is a reversible process whereby desorption can be favored over sorption under certain environmental conditions (e.g., low pH for metals). For organic compounds in general, as the molecular weight increases and the aqueous solubility decreases (i.e., low polarity and high hydrophobicity), the sorptive binding affinity increase (i.e., K_{oc} increases). The tendency for chemical constituents to adsorb to inorganic particulate and/or organic compounds is a particularly important process, because sorption to soil and/or sediment can effectively reduce a chemical constituent's mobility by tying up these chemicals within these matrices.

Biodegradation and Biotransformation Biodegradation is a result of the enzyme-catalyzed transformation of chemicals. Organisms require energy, carbon, and essential nutrients from the environment for their growth and maintenance. In the process, chemicals from the environment will be transformed by enzymes into a form that can be used by the organism. The biodegradation rate is the rate by which contaminants will be degraded. The rate is a function of microbial biomass and a chemical's concentration under given environmental conditions. When a pollutant is introduced into the environment, there is often a lag time before biodegradation begins as the organism generates an enzyme capable of

digesting the chemical. Cometabolism occurs when a pollutant can be biotransformed only in the presence of another compound that serves as a carbon and energy source (USEPA, 1979).

Bioaccumulation Bioconcentration and bioaccumulation data are an important parameter when evaluating the impact of chemicals in the aquatic environment. Hydrophobic chemicals can be partitioned into fat and lipid tissues and inorganic chemicals can be partitioned into bone marrow. The bioconcentration factor (BCF) is a measure of the concentration of a chemical in tissue (on a dry-weight basis) divided by the concentration in water and is a commonly used parameter to quantify bioconcentration (USEPA, 1979).

6.2.2 Persistence, Fate and Transport of PSC 51 Specific Contaminants

The HHRAs and ERAs (summarized in Sections 7.0 and 8.0) have identified organic compounds and metals that pose a significant risk to either human health or the environment. These constituents are summarized below by medium:

- Surface soil: arsenic.
- Groundwater: benzene, 1,1-DCE and vinyl chloride.

In addition, groundwater chemical-specific ARARs are regulatory standards that must be met. Therefore, chemicals that exceed their GCTLs are also considered in this section. These include benzene, TCE, 1,2- DCE, vinyl chloride, ethylbenzene, toluene, xylenes, naphthalene, and 2-methylnaphthalene. Three inorganic compounds (aluminum, iron and manganese) also were detected in various samples at concentrations exceeding their respective GCTLs. However, their concentrations did not exceed their respective background concentrations and, therefore, are considered naturally occurring conditions.

Surface Soil

Arsenic is a naturally-occurring element in the environment. Pure arsenic is a gray metal-like material usually found in the environment combined with other elements, such as oxygen, chlorine, and sulfur. As an elemental compound arsenic persists in the environment and does not experience significant degradation through the natural processes described above.

Arsenic was the only constituent in the surface soil determined by the risk assessment to be of concern. Possible transport processes of arsenic include movement of dust through via air movement and leaching of arsenic into the groundwater. Per Subsection 7.2.3.1 of this document, based on a qualitative screening exposures to fugitive dust released from the soil were found to be relatively insignificant.

Leaching of arsenic in the soil has yet to be a concern, as no concentrations have been detected in the groundwater.

Groundwater

The organic constituents detected in groundwater are VOCs and naphthalenes. This is consistent with the relatively mobile properties of these compounds. Other PAHs and SVOCs that were likely components of the materials released onto the soils at PSC 51 were not detected in groundwater, which is expected because they are relatively immobile. The more mobile constituents (e.g., benzene, vinyl chloride) were detected at concentrations exceeding GCTLs at greater distances from the source area than the less mobile constituents (e.g., TCE).

Without a continuing source of contamination to the groundwater of the surficial aquifer (contaminated soil removal), the concentrations of the organic COPCs in groundwater have decreased. This is displayed on Figure 5-3, on which most organic constituents have decreased significantly since the HLA sampling event. Natural processes are believed to be degrading the organic constituents at PSC 51. This is discussed further in the NA evaluation in Section 6.3.

The organic constituents detected at PSC 51, benzene and TCE along with its biodegradation compounds (e.g., 1,1-DCE, vinyl chloride) have been transported via groundwater flow. As noted in Section 5.0, the migration of these compounds appears to have been mostly horizontal in the surficial aquifer. In this aquifer, the groundwater flows predominantly to the southeast. No direct evidence of the chlorinated compounds or other VOCs or SVOCs migrating to the lower portion of the surficial aquifer was detected.

6.3 SUMMARY OF NATURAL ATTENUATION RESULTS

A suite of NA parameters were measured in the field and in the laboratory during the RI field sampling effort to determine the most likely pathway for any NA to be occurring. Field parameter measurements are presented in Table 6-1 and include DO, alkalinity, dissolved carbon dioxide, ferrous iron, manganese, hydrogen sulfide, pH, ORP, temperature and specific conductivity. NA field forms are included in Appendix H.

Laboratory analytical results are presented in Table 6-2 and include nitrogen species (nitrate/nitrite/ammonia/TKN), orthophosphate, chloride, dissolved sulfide, sulfate, dissolved iron, dissolved manganese, and methane/ethane/ethene. Additionally, the results of the natural attenuation sampling were evaluated in accordance with the guidance document Technical Protocol for Evaluating

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

¹ - Analyzed using CHEMetrics
² - Analyzed using HACH Digital Titrator AL-DT
⁵ - Analyzed using Horiba U-22 water quality instrument
 mg/L - milligrams per liter
 mS/cm - microsiemens per centimeter
 mV - millivolts

Table 6-2 (Continued)
Laboratory Analytical Results for Natural Attenuation
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Monitoring Well ID		MW-02	MW-04	MW-05	MW-06	MW-08	MW-09	MW-10
Sample Date		15-Dec-99	16-Dec-99	15-Dec-99	16-Dec-99	22-Dec-99	22-Dec-99	21-Dec-99
Parameter	Units							
Nitrate	mg/L	5.2	0.1 U	0.1 U	0.1 U	0.06	0.1 U	0.1 U
Nitrite	mg/L	0.5 U	0.1 U	0.2	0.1	0.1 U	0.1 U	0.1 U
Nitrogen-Ammonia as N	mg/L	NA	0.04 U	NA	0.06 U	0.06 U	0.07 U	0.1 U
TKN	mg/L	0.7	1 U	1 U	1 U	0.8 U	1 U	0.7 U
Orthophosphate	mg/L	0.04	0.1 U	0.1	0.1 U	0.1 U	0.05	0.09
Choride	mg/L	6	16	19	15	9	19	18
Dissolved Sulfide	mg/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Sulfate	mg/L	7	7	10	9	8	4 U	5 U
Dissolved Iron	mg/L	166 U	919	1120	1340	1700	1990	371
Dissolved Manganese	mg/L	9.4 U	49.9	29.2	30.4	12	58.2	40
Ethane	µg/L	0.5 U	20	0.5 U	5.1	0.5 U	0.5 U	1.5
Ethene	µg/L	0.044 J	2.7	0.047 J	0.16 J	0.5 U	1.7	0.77
Methane	µg/L	0.64 U	490	190	350	78	120	93

Notes:

U - Analyte not detected

J - Estimated value

mg/L - milligrams per liter

Natural Attenuation of Chlorinated Solvents in Groundwater (USEPA, 1998). Each of the measured parameters are discussed in the following sections.

The results of NA sampling at PSC 51 indicate that anaerobic conditions prevail in the co-mingled benzene and chlorinated solvent plume. The production of 1,2-DCE and vinyl chloride, breakdown products of the TCE starting material, indicates that reductive dechlorination is active within the plume. Inorganic species analyses suggest that sulfate reduction is active in the core of the plume. Anaerobic destruction of benzene is very inefficient however, its slow aerobic degradation consumes DO and helps maintain anaerobic conditions within the co-mingled plume, a prerequisite for reductive dechlorination of TCE.

Anaerobic conditions at the site, while favoring reductive dechlorination of TCE may inhibit the biological destruction of less chlorinated breakdown products (e.g., 1,2-DCE, vinyl chloride). As part of ongoing monitoring it will be imperative to evaluate any increases in the concentrations of the breakdown products and consider localized introduction of oxygen in the downgradient portion of the plume.

The individual NA processes and analytical parameters are discussed in the sections that follow.

6.3.1 Dissolved Oxygen

Geochemical measurements of DO were made in the field using a high-resolution, low-range test kit (HACH® Model OX-DT). DO is one of the most important of the geochemical parameters used to evaluate NA processes and is also the most difficult to collect accurately. Low-flow pumping and adherence to standard operating procedures were observed during DO analyses. The test kit for DO utilizes a digital titrator and the azide modification of the Winkler methodology (HACH 8215; USEPA 360.2). The test kit can obtain accurate determination of DO at concentrations as low as 0.02 mg/L and as high as 10 mg/L.

DO acts as a primary substrate or co-substrate during the initial stages of metabolism and is the single most efficient electron acceptor responsible for the biodegradation of natural or anthropogenic organic carbon. However, for highly chlorinated hydrocarbons, anaerobic pathways (e.g., reductive dechlorination) are more efficient than aerobic pathways. If DO concentrations are greater than approximately 1.0 mg/L, anaerobic bacteria cannot exist and reductive dechlorination will not occur.

During aerobic respiration, DO is used as an electron acceptor to mineralize natural organic carbon (or hydrocarbons) into carbon dioxide (CO₂) and water. DO at concentrations less than background provides strong evidence of indigenous bacterial populations that are already established and actively degrading

natural or anthropogenic carbon, utilizing aerobic pathways. However, once the available oxygen is used up, these aerobic processes will cease and the core of the plume will become anaerobic.

The DO concentrations ranged from 0.3 mg/L to 0.8 mg/L in the upgradient wells (nearer the FFTA). The maximum DO concentration in all wells was 1.5 mg/L in MW-05 on the upgradient edge of the dissolved benzene plume (see Figure 5-5). Wells upgradient of the benzene plume tend to have higher DO concentrations (e.g., 1 mg/L in DPT-05, 0.8 mg/L in MW-06) than some downgradient wells (e.g., 0.3 mg/L in MW-08). Twelve of 14 wells had DO concentrations less than 1.0 mg/L, which generally indicates that these wells contain organic carbon concentrations sufficient to produce anaerobic conditions. The organic carbon may be either naturally occurring carbon or anthropogenic contamination (e.g., benzene). The small amount of DO that is naturally present in the aquifer is apparently being used rapidly by bacteria, which thrive in aerobic conditions. The low DO results encountered during this monitoring event indicate generally anaerobic groundwater conditions across the site.

6.3.2 Dissolved Carbon Dioxide/Alkalinity

Dissolved carbon dioxide was measured in the field using a digital titrator (HACH Method 8205). Carbon dioxide is produced during aerobic respiration (oxygen utilization), as well as during anaerobic processes (e.g., iron reduction, sulfate reduction, etc.). In methanogenic environments, wherein oxygen, nitrate, manganese, ferric iron, and sulfate have been used as electron acceptors, bacteria will use carbon dioxide as an electron acceptor, generating methane as a byproduct. Therefore, carbon dioxide is both produced and used by different microbes during the biodegradation of a carbon source.

Dissolved carbon dioxide concentrations ranged from 18.3 mg/L (DPT-05) to 100 mg/L (MW-04). Lower concentrations were observed in the upgradient sample points (DPT-01 through DPT-03). The highest concentrations were observed in the core of the benzene plume and in downgradient wells. The distribution of dissolved carbon dioxide is consistent with the area of greatest biodegradation activity.

Alkalinity is a measure of the acid neutralizing capacity of water, usually expressed as mg/L of calcium carbonate (CaCO_3). Generally, alkalinity consists of three components, carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), and hydroxide (OH^-). Dissolved inorganic carbon (DIC) is comprised of the sum of the carbonate and bicarbonate ion concentrations and is often a good measure of the dissolved carbon dioxide generated during aerobic or anaerobic reduction of contaminants in a plume.

At PSC 51 the field-measured alkalinity ranged from 2.1 mg/L (DPT-03) to 331 mg/L (MW-10). There is a general tendency for the alkalinity to be higher in benzene plume and other downgradient wells. This

trend is consistent with the expected trend in biodegradation but may also be related to the influence of higher alkalinity, saline waters in the southern and deeper areas of the site.

6.3.3 Nitrogen/Orthophosphate

Nitrate and nitrite analyses were measured by the fixed-based lab using the following nitrogen methods: ammonia, nitrate, nitrite, and TKN.

After DO has been depleted through aerobic respiration, anaerobes will use nitrate (NO_3^-) as an electron acceptor to anaerobically degrade hydrocarbons (denitrification). This process reduces nitrate to nitrite (NO_2^-) and generates carbon dioxide. However, because chlorinated hydrocarbons are used as electron acceptors during reductive dechlorination, nitrate may actually compete as an electron acceptor if present at concentrations greater than 1.0 mg/L.

The concentrations of nitrate were less than 0.1 mg/L, with the exception of three monitoring wells, which had concentrations of 1.1 mg/L (DPT-05), 5.2 mg/L (MW-02), and 5.8 mg/L (DPT-02). Two of these wells (MW-02 and DPT-02) are nearer the FFTA (the area without VOC and SVOC contamination). Further, the nitrite concentrations were below method detection limits for all of the samples except four, and the highest nitrite concentration was 0.2 mg/L. The elevated nitrate concentrations measured in two upgradient wells may not be characteristic of background nitrate concentrations at the site. However, the low concentrations of nitrate and undetectable nitrite in the area of greatest VOC contamination is consistent with anaerobic site conditions.

Nitrogen (as measured in the form of either ammonia or TKN), along with phosphorous (measured as orthophosphate) and other inorganic salts, are important nutrients for microbial growth. One factor controlling the rate of biological activity is a sufficient supply of required nutrients in the mobile phase. Ideal nutrient concentrations are in the range of 0.005 to 0.02 percent by weight (USEPA, 1992a). Nitrogen (as ammonia) was not detected above method detection limits in any of the wells analyzed. Concentrations of TKN were below detection limits except for four monitoring wells where the concentrations ranged from 0.2 mg/L to 2 mg/L. Orthophosphate concentrations were generally below detection limits with the exceptions being very low concentrations measured in MW-02 (upgradient) and some of the deeper downgradient wells (e.g., MW-09, MW-10). The generally low concentrations of nutrient nitrogen and phosphate in the aquifer may limit the microbial biodegradation of contaminants. However, low concentrations may also indicate increased microbial activity with rapid recycling of nutrients.

6.3.4 Dissolved Iron/Ferric Iron/Ferrous Iron and Manganese

Dissolved (total) iron was analyzed at the fixed-based laboratory. Field measurements of dissolved ferrous iron were made in the field using a high-resolution, low-range, portable colorimeter (HACH®). The colorimeter utilizes the 1,10-phenanthroline, iron reagent method (HACH® 8146; Modified Standard Method). The colorimeter can obtain a quite accurate (± 0.017 mg/L standard deviation) determination of ferrous iron with an estimated minimum detection limit of 0.03 mg/L and a maximum detection of 3.0 mg/L. The manganese determination was performed in the field using a portable colorimeter (HACH® 8034). The colorimeter can obtain a quite accurate (± 0.18 mg/L standard deviation) determination of manganous ion (Mn^{+2}) with an estimated minimum detection limit of 0.12 mg/L and a maximum detection of 20.0 mg/L.

After DO and nitrate reduction have occurred, anaerobic microbes will use manganese oxides (Mn^{+4}) and ferric iron (Fe^{+3}) (present in iron oxides) as electron acceptors (manganese and iron reduction) to anaerobically degrade hydrocarbons, generating manganous (Mn^{+2}) manganese and ferrous iron (Fe^{+2}) and carbon dioxide. Ferric iron concentrations are either determined separately or calculated by subtracting ferrous iron (Fe^{+2}) concentrations from total iron. The majority of ferric iron that is reduced to ferrous iron precipitates out upon contact with an oxygenated source such as surface water.

Total iron concentrations ranged from 5280 mg/L to 200 mg/L, indicating a sufficient supply of iron to act as a potential electron receptor. Ferrous iron ranged from non-detect to 0.76 mg/L in DPT-01. There is no discernible increase in ferrous iron concentration in wells within or downgradient of the HDA.

Field determined manganese concentrations ranged from 3.3 mg/L (DPT-04) to non-detect (DPT-01). The highest concentrations of dissolved manganese are observed in the well with low DO (DPT-04) and downgradient benzene plume wells (e.g., MW-51-06, MW-08, MW-09). The distribution of dissolved manganese is consistent with the anaerobic conditions at the site, especially within the benzene plume.

6.3.5 Sulfate/Sulfide

Sulfate and total sulfide concentrations were analyzed at the fixed-based laboratory. After DO, nitrate, and ferric iron have been used, anaerobic microbes will use sulfate (SO_4^{-2}) as an electron acceptor to anaerobically degrade hydrocarbons (sulfate reduction). The process of sulfate reduction results in the generation of sulfide and carbon dioxide. Sulfate reduction, along with methanogenesis, is one of the most important and frequently documented reduction pathways responsible for NA of chlorinated hydrocarbon plumes. However, as previously discussed, chlorinated hydrocarbons are used as electron acceptors during reductive dechlorination. Therefore, sulfate may compete as an electron acceptor if present at concentrations greater than 20 mg/L. In order for reductive dechlorination to occur, sulfate

needs to be present but at concentrations less than 20 mg/L. However, it has been documented that in high concentration plumes, dechlorination may still occur despite high sulfate concentrations (USEPA, 1998a).

Sulfate concentrations ranged from a maximum of 15 mg/L in DPT-03, upgradient of the current benzene plume, to non-detect in more downgradient wells MW-51-06, MW-09, and MW-10. None of the measured sulfate concentrations exceed 20 mg/L. The pattern of higher upgradient concentrations and lower concentrations within the plume support is consistent with a model of anaerobic conditions prevailing within the benzene plume. As mentioned previously, sulfate reduction results in the generation of sulfide and carbon dioxide. Sulfide can be present in many forms, the primary forms being the sulfide ion present in soluble salts (S^{2-}) and as dissolved hydrogen sulfide (as H_2S or HS^-). Since hydrogen sulfide exists as a dissolved gas in groundwater, the fixed-based laboratory analysis typically reflects the sulfide ion concentration alone.

The maximum sulfide concentration determined in the laboratory analyses was 1.4 mg/L in the upgradient sample location DPT-03. All other dissolved sulfide laboratory analysis results were less than the detection limit. Field measured hydrogen sulfide concentrations may be more representative of site conditions given the volatility of hydrogen sulfide. Measurable hydrogen sulfide concentrations in the field were observed in two locations, DPT-04 (0.7 mg/L) and MW-04 (0.3 mg/L). Monitoring well MW-04 is located near the center of the current benzene plume and DPT-04 is also the location of the lowest DO concentration. In summary, sulfate reduction does appear to be an active anaerobic pathway for dechlorination of the hydrocarbon plume, as evidenced by generally lower concentrations of sulfate in downgradient wells.

6.3.6 Oxidation-Reduction Potential

The Eh was analyzed using a portable, water-quality probe used in conjunction with a flow-through sample chamber to reduce sample aeration and contact with the atmosphere.

The Eh is a measure of the relative tendency of the groundwater solution to accept or donate electrons and of the amount of energy released during electron transfers within the solution. The Eh depends upon and influences the rates and types of biodegradation processes. Therefore, the measurement of Eh [in millivolts (mV)] can provide evidence of the type of biodegradation processes that are active in a particular plume or even within different portions of the same plume. Great care must be taken during the evaluation of Eh data since most natural waters usually include mixed potentials, which cannot be related to a single electron couple. Therefore, Eh should be used only as a qualitative indicator of the overall oxidation/reduction state.

The relative Eh measurement is proportional to the efficiency of the bioremediation pathway. For example, the most efficient bioremediation pathway for a petroleum hydrocarbon plume is aerobic respiration. During aerobic respiration, oxygen is utilized as the electron acceptor to mineralize petroleum hydrocarbons into CO₂ and water. The Eh value for such a reaction is theoretically in the range of +800 mV.

Following is a general comparison of common metabolic pathways and related Eh measurements, quantified under laboratory conditions:

Pathway	Electron Acceptor	Eh (mV)
Aerobic Respiration	Oxygen	+820
Denitrification	Nitrate	+740
Manganese Reduction	Manganese	+520
Iron Reduction	Ferric Iron	-50
Sulfate Reduction	Sulfate	-220
Methanogenesis	Carbon dioxide	-240
Reference: AFCEE (1996)		

During the sampling event, Eh values across the site ranged from -137 mV to +307 mV. The most positive Eh value was observed in the most upgradient well, MW-02. The most negative value was observed in the deep, downgradient well MW-10. There appears to be a slight trend in the Eh values collected at the site, such that the greater negative values are associated with contaminated wells or low DO locations (e.g., DPT-04) and the downgradient flow direction. In general, the Eh values fall in the range of values characteristic of the manganese reduction pathway, consistent with the distribution of field-measured manganese discussed previously.

6.3.7 Methane/Ethene/Ethane

Methanogenesis is an anaerobic biodegradation process whereby methane-producing microbes utilize carbon dioxide as an electron acceptor and generate methane as a byproduct of fermentation. Because methane is not a chemical component of fuels or solvents, its presence above background concentrations provides strong evidence of methanogenic fermentation (and carbon dioxide utilization). Background concentrations of methane are important since some natural sources of methane could exist (e.g., groundwater derived from infiltration into or through a peat bog or other natural methane source).

Dissolved methane concentrations were determined in the laboratory. The upgradient concentrations range from non-detect (MW-02, DPT-02, and DPT-03) to 1.4 µg/L (DPT-01). Downgradient sample results range from 490 µg/L (MW-04) to 0.43J µg/L (MW-51-06). The highest concentrations are observed in the line of wells that define the highest benzene concentration zone in the plume. Methane concentrations downgradient, although elevated above those observed near the FFTA, are lower.

Under strictly anaerobic conditions, ethene and methane can be produced by the biotic dechlorination of vinyl chloride. Concentration of ethene greater than 10 µg/L provide strong evidence of such dechlorination. This process is less efficient than direct oxidation of vinyl chloride to carbon dioxide in an aerobic environment, and thus can lead to the accumulation of vinyl chloride.

Dissolved ethene was measured in samples submitted to the laboratory. Most dissolved ethene concentrations were low and thus estimated. However, measurable ethene concentrations were observed at MW-04 (2.7 µg/L), MW-09 (1.7 µg/L), and MW-51-06 (0.76 µg/L), which were wells associated with the vinyl chloride plume (Figure 5-8).

Dissolved ethane is produced by continued biotic degradation of ethene. Dissolved ethane concentrations were determined in the laboratory. The results were similar to those of dissolved ethene with the highest concentrations observed in MW-04 (20 µg/L), MW-06 (5.1 µg/L), and MW-10 (1.5 µg/L). The highest concentration in MW-04 is consistent with the methane and ethene and supports the conclusion that anaerobic pathways for reductive dechlorination are active at the site.

6.3.8 pH

During the sampling event, a Horiba® Model U-10 water-quality meter was used to collect groundwater temperature, pH, turbidity, specific conductance, and DO. The meter was intended to determine general groundwater quality parameters and to assist in the determination of appropriate monitoring well purge volumes. The DO measurements collected from the Horiba® were used solely for the determination of appropriate monitoring well purge volumes.

pH is a measurement of the hydrogen ion (H^+) concentration in terms of its negative logarithm. The scale ranges from 0 to 14; values less than 7 indicate acidity and values greater than 7 indicate basic solutions. pH affects the presence and efficiency of bacterial populations in natural groundwater conditions. Neutral groundwater (i.e., pH 7) is the preferred condition for most microbes.

The pH values collected during the sampling event ranged from 4.96 (DPT-02) to 7.61 (MW-10) with lower pH values in upgradient wells and higher values downgradient and deeper. The increase in pH

correlates with increases in specific conductivity and may reflect increasing influence of higher pH saline water in the southern and deeper portion of the site. This indicates generally neutral groundwater in the area of the plume, which is conducive to intrinsic bioremediation.

6.3.9 Specific Conductivity

Specific conductivity [microsiemens per centimeter (mS/cm)] is a measure of a solution's ability to carry an electrical current and is controlled by the different quantities and types of ions in the solution. Generally, conductivity increases as ion concentration increases and can fluctuate within a plume based upon the geochemistry at that particular location. Conductivity is most frequently used as an indicator of a consistent groundwater source. For example, different water sources may have significantly different conductivity values.

Specific conductivity values ranged from 4.9 mS/cm (DPT-03) to 70.4 mS/cm (MW-10), with a general tendency of greater values in the more downgradient and deeper wells. This trend suggests a generally increasing influence on groundwater of more saline water.

6.3.10 Chloride

Chloride concentrations are used to evaluate NA because chloride is released into groundwater during reductive dechlorination of chlorinated solvents. Therefore, an increase in chloride ion concentration in the downgradient direction is direct evidence of dechlorination.

Chloride concentrations at PSC 51 were determined in the laboratory. The results range from 5 mg/L (upgradient microwell DPT-01) to 24 mg/L (MW-51-06). Chloride concentration trends are consistent with reductive dechlorination in the core of the benzene plume. The lowest observed concentrations are in upgradient wells and the highest concentrations are observed in wells downgradient of the source area (MW-04). Elevated chloride concentrations further downgradient and in deeper wells may reflect the influence of more saline waters discussed earlier.

6.3.11 Temperature

The temperature of groundwater affects the solubility of oxygen and other geochemical species, as well as the metabolic activity bacteria. Microbes are generally more active in warm water. The rate of hydrocarbon bioremediation doubles for every 10-degree Celsius (°C) increase in temperature (referred to as the "Q₁₀" rule) in the range of 5 to 25 °C (AFCEE, 1996)

Groundwater temperatures during the sampling event ranged from 8°C (MW-04) to 18.88°C (DPT-01). These temperatures are well within the range of values acceptable for bioremediation to take place.

6.3.12 Initial Scoring of NA Conditions at PSC 51

Table 6-3 presents the initial screening results for NA at PSC 51 based on the results discussed in the previous subsections. Table 6-3 uses the scoring method from Table 2.3 of the guidance document *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (USEPA, 1998). As indicated below the scoring for PSC 51 indicates a screening score of 25. According to the guidance document, a score of greater than 20 indicates strong evidence for anaerobic biodegradation of chlorinated organics.

Table 6-3
Natural Attenuation Scoring for PSC 51

Analysis	Concentration in Most Contaminated Zone	Interpretation	Value	PSC 51 Score
Oxygen	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	3
Oxygen	>5 mg/L	Not tolerated; however VC may be oxidized aerobically	-3	--
Nitrate	<1 mg/L	At higher concentrations may compete with reductive pathway	2	2
Iron II	>1 mg/L	Reductive pathway possible; VC may be oxidized under Fe(III) reducing conditions	-3	--
Sulfate	<20 mg/L	At higher concentrations may compete with reductive pathway	2	2
Sulfide	>1 mg/L	Reductive pathway possible	3	--
Methane	<0.5 mg/L	VC oxidizes	0	
	>0.5 mg/L	Ultimate reductive daughter product, VC accumulates	3	3
ORP	<50 mV	Reductive pathway possible	1	1
	<-100mV	Reductive pathway likely	2	
pH	5< pH <9	Optimal range for reductive pathway	0	0
	5> pH >9	Outside optimal range for reductive pathway	-2	
TOC	>20 mg/L	Carbon and energy source; drives dechlorination	2	--
Temperature	>20C	At T>20C biochemical process is accelerated	1	--
Carbon Dioxide	>2x background	Ultimate oxidative daughter product	1	1
Alkalinity	>2x background	Results from interaction between CO2 and aquifer materials	1	--
Chloride	>2x background	Daughter product of organic chlorine	2	2
Hydrogen	>1 nM	Reductive pathway possible, VC may accumulate	3	NA
Hydrogen	<1 nM	VC oxidized	0	NA
Volatile fatty acids	>0.1 mg/L	Intermediates resulting from biodegradation of more complex compounds; carbon and energy source	2	NA
BTEX	>0.1 mg/L	Carbon and energy source; drives dechlorination	2	2
Tetrachloroethene		Material released	0	0
TCE		Material released	0	
		Daughter product of PCE	2	2
DCE		Material released	0	
		Daughter product of TCE	2	2
VC		Material released	0	
		Daughter product of DCE	2	2
1,1,1-Trichloroethane		Material released	0	--
DCA		Daughter product of TCA under reducing conditions	2	--
Carbon Tetrachloride		Material released	0	--
Chloroethane		Daughter product of DCA or VC under reducing conditions	2	--
Ethene/Ethane	>0.01 mg/L	Daughter product of VC/ethene	2	
	>0.1 mg/L		3	3
Chloroform		Material released	0	--
		Daughter product of Carbon Tetrachloride	2	
Dichloromethane		Material released	0	--
		Daughter product of Chloroform	2	
Total Score			25	

7.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The baseline HHRA contained in this section was performed to characterize and quantify potential health risks at PSC 51 at the NAS Jacksonville in the absence of further remedial action. The results of the baseline HHRA are also used to focus the evaluation of remedial action alternatives, if action is required. The baseline HHRA consists of five major components:

- Data evaluation.
- Exposure assessment.
- Toxicity assessment.
- Risk characterization.
- Uncertainty analysis.

Methods for selection of COPCs to be evaluated quantitatively in the baseline HHRA, as well as those chemicals identified as COPCs for PSC 51, are described in Section 7.1, Data Evaluation. The data evaluation section is primarily concerned with the selection of COPCs that are representative of the type and magnitude of potential human health effects. The COPC screening process involves the comparison of maximum site concentrations to risk-based screening levels and other health-based standards. Recent and historical data available for the site are considered during the selection process. A brief discussion of data usability is also provided.

Section 7.2, Exposure Assessment, identifies potential receptor populations and exposure pathways by which receptors may come in contact with contaminants at the site. Potential exposure routes under current and future land uses are developed from information on source area, chemical concentrations, chemical release mechanisms, patterns of human activity, and other pertinent information. A concise conceptual site model illustrates the potential receptors and exposure pathways evaluated in the baseline risk assessment. The exposure assessment also includes the calculation of quantitative estimates of chemical intake for each identified receptor, pathway, and route of exposure under the reasonable maximum exposure (RME) scenario. Equations and relevant exposure input parameters used in estimating chemical intakes are provided.

Section 7.3, Toxicity Assessment, presents the chemical-specific toxicity criteria for the identified COPCs, which are used in the quantification of potential human health risks. These toxicity criteria, when integrated with the estimated chemical intakes developed in the exposure assessment, provide the basis for quantifying potential human health risks.

Methods used for characterizing risks associated with noncarcinogenic and carcinogenic effects for exposure to COPCs are provided in Section 7.4, Risk Characterization. Actual numerical results of the baseline HHRA for PSC 51 are summarized.

Because the quantitative risk estimates developed in the risk characterization are based on a number of assumptions (concerning exposure, land use, toxicity, etc.), various uncertainties are associated with the risk assessment process. A brief discussion of the uncertainties associated with the risk evaluation for PSC 51 is contained in Section 7.5, Uncertainty Analysis.

To assess potential public health risks, four major aspects of chemical contamination and exposure must be considered: (1) contaminants with toxic characteristics must be found in environmental media; (2) the contaminants must be released by either natural processes or by human action; (3) potential exposure points must exist; and (4) human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure; without one of the factors listed above, there is no risk.

An illustration of the baseline HHRA process is provided in Figure 7-1.

The baseline HHRA for PSC 51 was conducted using the most recent guidance from the USEPA (USEPA 1989, 1991, 1992b, and 1997a), including Regional Supplemental Guidance (USEPA Region IV, 1995b) and also considers FDEP guidance. This baseline human health methodology follows the methodology presented in the Remedial Investigation/Feasibility Study Field Sampling Plan for Potential Source of Contamination 51, Naval Air Station Jacksonville (TtNUS, 1999a).

7.1 DATA EVALUATION

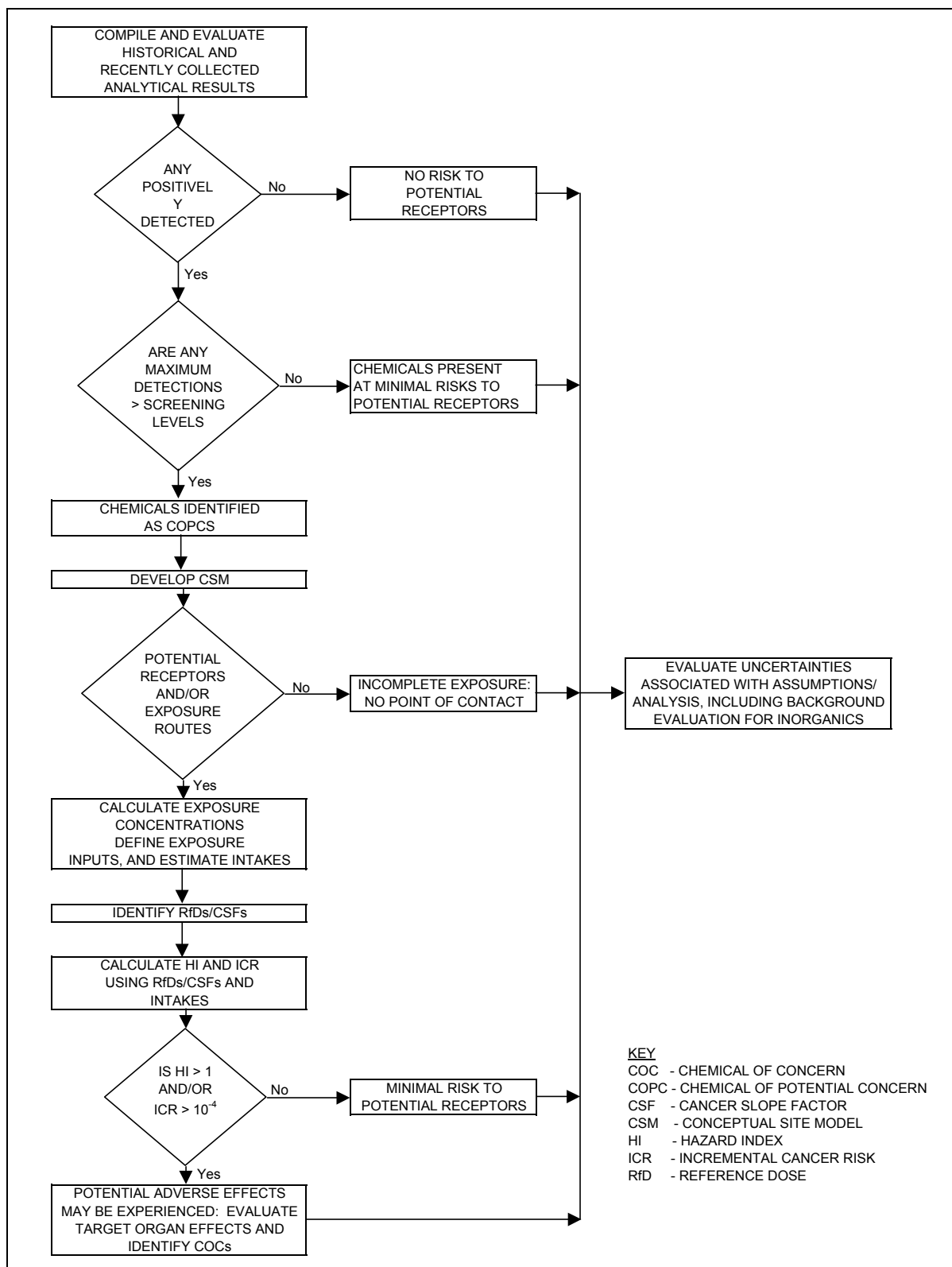
Data evaluation is a site-specific task that uses a variety of information to determine which of the detected chemicals at a site are most likely to present a risk to potential human receptors. The end result of this qualitative selection process is a list of COPCs for each environmental medium under consideration. Subsection 7.1.1 provides a brief summary of data usability, as it pertains to the baseline HHRA. The selection of COPCs for the site is contained in Subsection 7.1.2.

7.1.1 Data Usability

This section addresses the usability of data collected as part of the 1999 RI/FS field investigation. The use of an approved workplan for the 1999 RI/FS promotes quality by identifying appropriate sample locations, analytical parameters, analytical methods, and DQOs. The results of measures (field and

FIGURE 7-1
SUMMARY OF HUMAN HEALTH RISK ASSESSMENT PROCESS
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida



laboratory quality control, data validation, etc.) taken to ensure the quality of data collected during the 1999 RI/FS field investigation, are summarized in Appendix F of this report. All sample data collected for PSC 51 were used to assess potential human health risks. The qualification of data during the formal data validation process is not expected to compromise the results of the baseline HHRA. Analytical data qualified as estimated were utilized, even though the reported positive concentrations or sample-specific quantitation limits may be somewhat imprecise. The use of estimated data adds to the uncertainty associated with the risk assessment; however, the associated uncertainty is expected to be negligible compared to the other uncertainties inherent in the risk evaluation process (i.e., uncertainties with land uses, exposure scenarios, toxicological criteria, etc.).

7.1.2 Selection of COPCs

The overall goal of the baseline HHRA is to quantify risks associated with those chemicals that represent a potentially significant human health hazard on the basis of toxicity, environmental concentration, and mobility. USEPA guidance (USEPA, 1989 and USEPA, Region IV, 1995b) recommends focusing the baseline risk assessment by quantifying risk only for a select list of COPCs at a site. These chemicals, which are a subset of all detected chemicals in a given medium, are defined as those chemicals likely to dominate the overall potential risks for a site.

For the purposes of this baseline risk assessment, COPCs for a particular medium are limited to those chemicals that exceed a selection criterion. The maximum concentration of a chemical detected in soil, groundwater, surface water, and sediment was compared to the RBCs for that chemical. RBCs for chemicals have been determined for cancer risk levels of 1×10^{-6} and noncancer (hazard quotient) levels of 1.0 and are presented in the most recent version of the USEPA Region III Risk-Based Concentration Table (USEPA, 2000a). The values in the RBC table were divided by 10 for noncarcinogens to screen to the more conservative hazard quotient (HQ) of 0.1. Concentrations of chemicals in soil will also be compared to FDEP SCTL. Chemicals detected in groundwater and surface water were retained as COPCs if the maximum concentration detected exceeds the RBC for tap water or the FDEP GCTLs. The maximum concentrations of chemicals detected in soil or sediment were compared to Region III residential RBCs and FDEP SCTLs for soil. USEPA soil screening levels (SSLs) for transfer to soil or groundwater were used to evaluate the inhalation pathway. USEPA SSLs (USEPA, 1996a) and FDEP SCTLs were used to evaluate the potential for chemicals to migrate from soil to groundwater. Chemicals with concentrations exceeding these screening criteria will be retained as COPCs.

Inorganic COPCs were also selected based on a comparison of site-specific chemical concentrations to background chemical concentrations. Comparisons were made between the maximum concentration of the site-specific chemical and twice the mean of the background chemical concentration. If the maximum

detected concentration was less than twice the mean of the background chemical concentrations, then that chemical was not retained as a COPC.

The initial list of COPCs for an area under investigation will include any chemical detected at least once in validated environmental samples from the area. Essential human nutrients (magnesium, potassium, calcium, and sodium) were screened against essential nutrient screening criteria developed by HLA (1999b) and originally presented in the *Remedial Investigation and Feasibility Study, Operable Unit 3, Naval Air Station Jacksonville*. Recommended daily allowances advocated by the Food and Nutrition Board are used for the calculation of the essential nutrient screening concentrations. The development of the essential nutrient screening levels is presented in Appendix J.

Maximum detected concentrations (in a single sample) in each sample medium for PSC 51 were compared to the risk-based and health-based screening criteria. If the maximum concentration exceeded any of the screening criteria, that chemical was retained as a COPC for all significant exposures involving that medium. For example, if arsenic was retained for soil, this chemical was evaluated as a COPC for both ingestion and dermal exposure routes. If none of the chemicals detected in a medium exceeded screening criteria, that medium was dropped from further consideration and the potential risks associated with exposure to that medium are regarded as relatively insignificant.

Table 7-1 summarizes the screening criteria used in the selection of COPCs. The results for the selection process is provided in the remainder of this section. No subsurface soil data was collected during the 1999 RI/FS field investigation; consequently, no COPCs were identified for subsurface soil.

7.1.2.1 Surface Soil

Four surface soil samples were collected at PSC 51 and analyzed for inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 7-2. Arsenic and iron were detected at concentrations that exceeded the screening criteria; therefore, these chemicals will be retained as COPCs for the HHRA.

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

(1) - USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = $1\text{E-}06$, HI = 1.0)
 (2) - USEPA Soil Screening Level Guidance: Technical Background Document. May 1996.
 (3) - FAC 62-777
 (4) - Value is for cis-1,2-DCE.
 (5) - Value is for 2-methylnaphthalene.
 (6) - Leachability values may be derived using the SPLP Test to calculate site-specific SCLTs or may be determined using TCLP in the event oily wastes are present (FDEP, 1999).
 (7) - Value is for hexavalent chromium.
 (8) - OSWER Directive # .9355.4-12.
 (9) - Action Level USEPA Drinking Water Standards and Health Advisories, Summer 2000.

Definitions:
 NA = Not Available
 C = Carcinogenic

sat = saturation concentration
 N = Non-Carcinogenic

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Notes:	
(1) Minimum/maximum detected concentration.	Definitions: N/A = Not Applicable
(2) Background value for inorganics is two times the mean background concentration	COPC = Chemical of Potential Concern
(3) USEPA Region III Residential Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)	ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
(4) Soil Cleanup Target Levels taken from Table II; FAC 62-777, August 1999.	J = Estimated Value
(5) Rationale Codes Selection Reason: Above Screening Levels (ASL)	C = Carcinogenic
Deletion Reason: Background Levels (BKG)	N = Non-Carcinogenic
No Toxicity Information (NTX)	FDEP = Florida Department of Environmental Protection
Essential Nutrient (NUT)	mg/kg = milligrams per kilogram
Below Screening Level (BSL)	
(6) Essential nutrient screening level based on recommended dietary allowances (HLA, 1999).	Bold rows are COPCs.
(7) Value is for hexavalent chromium.	
(8) OSWER Directive # 9355.4-12	

Concentrations of all chemicals detected in surface soil were less than the USEPA SSLs for migration from soil to air (Table 7-3); therefore, the inhalation pathway will not be evaluated quantitatively.

Maximum detected concentrations in surface soil were also compared to USEPA and FDEP SSLs for migration to groundwater, as summarized in Table 7-4. Concentrations of all chemicals detected in surface soil were less than the screening criteria for migration from soil to groundwater.

7.1.2.2 Groundwater

Fourteen groundwater samples were collected at PSC 51 and analyzed for VOCs, SVOCs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 7-5. The following chemicals were detected at maximum concentrations in groundwater that exceeded the risk-based COPC screening levels.

- VOCs [1,1-DCE, 1,2-dichloroethane, 1,2-DCE (total), benzene, bromodichloromethane, chloroform, TCE, and vinyl chloride]
- SVOCs [2-methylnaphthalene, naphthalene]

Maximum detected concentrations of aluminum, antimony, arsenic, cadmium, iron, and manganese exceeded the screening criteria but were within background concentrations; consequently, these chemicals will not be retained as COPCs in the HHRA.

7.1.2.3 Surface Water

Three surface water samples were collected at PSC 51 and analyzed for VOCs. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 7-6. The concentrations of all chemicals in surface water were less than the risk-based COPC screening levels. Consequently, there are no COPCs identified for surface water at PSC 51.

7.1.2.4 Sediment

Three sediment samples were collected at PSC 51 and analyzed for VOCs. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 7-7. The concentrations of all chemicals in sediment were less than the risk-based COPC screening levels. Consequently, there are no COPCs identified for sediment at PSC 51.

Table 7-3
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Migration from Soil to Air

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CAS Number	Chemical	Minimum ⁽¹⁾ Concentration	Maximum ⁽¹⁾ Concentration	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value	Screening ⁽³⁾ Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for ⁽⁴⁾ Contaminant Deletion or Selection
Inorganics - (mg/kg)													
7429-90-5	Aluminum	2010	6410	S003	4/4	NA	6410	1340	NA	NA	NA	No	NTX
7440-38-2	Arsenic	0.48 B	3.7	S004	4/4	NA	3.7	0.8	750	NA	NA	No	BSL
7440-70-2	Calcium	92.7 B	465 J	S003	4/4	NA	465	2360	NA	NA	NA	No	NUT, BKG
7440-47-3	Chromium	5.4	16	S003	4/4	NA	16	6.6	270 ⁽⁵⁾	NA	NA	No	BSL
7439-89-6	Iron	228	9620	S004	4/4	NA	9620	852	NA	NA	NA	No	NTX
7439-92-1	Lead	3.3	188	S003	4/4	NA	188	14.4	NA	NA	NA	No	NTX
7439-95-4	Magnesium	471	479 J	S004	2/4	551 - 565	479	99.8	NA	NA	NA	No	NUT
7440-62-2	Vanadium	1.8	15.1	S004	4/4	NA	15.1	3.8	NA	NA	NA	No	NTX
7440-66-6	Zinc	2 J	19.2	S003	3/4	7.1	19.2	15.2	NA	NA	NA	No	NTX

Notes:

- [illegible]

Definitions: N/A = Not Applicable
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

- (5) Value is for hexavalent chromium.

Table 7-4
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Migration from Soil to Groundwater

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CAS Number	Chemical	Minimum ⁽¹⁾ Concentration	Maximum ⁽¹⁾ Concentration	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value ⁽²⁾	Screening ⁽³⁾ Toxicity Value	Potential ⁽⁴⁾ ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for ⁽⁵⁾ Contaminant Deletion or Selection
Inorganics (mg/kg)													
7429-90-5	Aluminum	2010	6410	S003	4/4	NA	6410	1340	NA	(6)	(6)	No	NTX
7440-38-2	Arsenic	0.48 B	3.7	S004	4/4	NA	3.7	0.8	29	29	FDEP	No	BSL
7440-70-2	Calcium	92.7 B	465 J	S003	4/4	NA	465	2360	NA	(6)	(6)	No	NUT, BKG
7440-47-3	Chromium	5.4	16	S003	4/4	NA	16	6.6	38 (7)	38 (7)	FDEP	No	BSL
7439-89-6	Iron	228	9620	S004	4/4	NA	9620	852	NA	(6)	(6)	No	NTX
7439-92-1	Lead	3.3	188	S003	4/4	NA	188	14.4	NA	(6)	(6)	No	NTX
7439-95-4	Magnesium	471	479 J	S004	2/4	551 - 565	479	99.8	NA	(6)	(6)	No	NUT
7440-62-2	Vanadium	1.8	15.1	S004	4/4	NA	15.1	3.8	6000	980	FDEP	No	BSL
7440-66-6	Zinc	2 J	19.2	S003	3/4	7.1	19.2	15.2	12000	6000	FDEP	No	BSL

Notes:

(1) Minimum/maximum detected concentration.

(2) Background value for inorganics is two times the mean background concentration.

(3) USEPA Soil Screening Guidance, July 1996.

(4) SCTLs taken from Table II; FAC 62-777, August 1999.

(5) Rationale Codes Selection Reason: Above Screening Levels (ASL)

Deletion Reason: Background Levels (BKG)

No Toxicity Information (NTX)

Essential Nutrient (NUT)

Below Screening Level (BSL)

(6) Leachability values may be derived using the SPLP Test to calculate site-specific SCTLs or may be determined using TCLP in the event oily wastes are present (FDEP, 1999).

(7) Value is for hexavalent chromium.

Definitions: N/A = Not Applicable

J = Estimated Value

C = Carcinogenic

N = Non-Carcinogenic

Table 7-5
Occurrence, Distribution and Selection of Chemicals of Potential Concern
Direct Contact With Groundwater

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CAS Number	Chemical	Minimum ⁽¹⁾ Concentration	Maximum ⁽¹⁾ Concentration	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background ⁽²⁾ Value	Screen ⁽³⁾ Toxicity Value	Potential ⁽⁴⁾ ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection ⁽⁵⁾
Volatile Organic Compounds -(µg/L)													
75-35-4	1,1-DCE	0.2 J	1.2 J	MW-04	6/14	1	1.2	NA	0.044 C	7	FDEP	Yes	ASL
107-06-2	1,2-Dichloroethane	0.33 J	0.33 J	MW-51-05	1/14	1 - 5	0.33	NA	0.12 C	3	FDEP	Yes	ASL
540-59-0	1,2-DCE	0.94 J	64	MW-04	7/14	1	64	NA	5.5 N	63	FDEP	Yes	ASL
78-93-3	2-Butanone	2.5 J	2.5 J	MW-10D	1/14	10 - 50	2.5	NA	190 N	4200	FDEP	No	BSL
108-10-1	4-Methyl-2-pentanone	0.79 J	0.79 J	MW-10D	1/14	10	0.79	NA	14 N	560	FDEP	No	BSL
67-64-1	Acetone	1.4 J	21 J	MW-10D	3/14	10 - 50	21	NA	61 N	700	FDEP	No	BSL
71-43-2	Benzene	1.3	120	MW-04	8/14	1	120	NA	0.32 C	1	FDEP	Yes	ASL
75-27-4	Bromodichloromethane	0.26 J	0.26 J	MW-09I	1/14	1 - 5	0.26	NA	0.17 C	0.6	FDEP	Yes	ASL
75-15-0	Carbon disulfide	0.14	13	MW-10D	4/14	1 - 5	13	NA	100 N	700	FDEP	No	BSL
67-66-3	Chloroform	0.86 J	1.4	MW-09I	2/14	1 - 5	1.4	NA	0.15 C	5.7	FDEP	Yes	ASL
74-87-3	Chloromethane	0.086 J	0.086 J	MW-10D	1/14	2 - 10	0.086	NA	2.1 C	2.7	FDEP	No	BSL
100-41-4	Ethylbenzene	0.17 J	20	MW-04	4/14	1	20	NA	130 N	30	FDEP	No	BSL
75-09-2	Methylene Chloride	0.27 J	0.74	DPT-04	3/14	1 - 5	0.74	NA	4.1 C	5	FDEP	No	BSL
108-88-3	Toluene	0.054 J	2.8 J	MW-04	5/14	1	2.8	NA	75 N	40	FDEP	No	BSL
79-01-6	TCE	0.097	4.7 J	MW-04	8/14	1	4.7	NA	1.6 C	3	FDEP	Yes	ASL
75-01-4	Vinyl chloride	1.5 J	2.9	MW-51-05	4/14	2 - 10	2.9	NA	0.019 C	1	FDEP	Yes	ASL
1330-20-7	Xylenes (total)	2.3	20	MW-04	3/14	1	20	NA	1200 N	20	FDEP	No	BSL

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CAS Number	Chemical	Minimum Concentration ⁽¹⁾	Maximum ⁽¹⁾ Concentration	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background ⁽²⁾ Value	Screen ⁽³⁾ Toxicity Value	Potential ARAR/TBC Value ⁽⁴⁾	Potential ARAR/TBC Source	COPC Flag	Rationale for ⁽⁵⁾ Contaminant Deletion or Selection	
	Semivolatile Organic Compounds (µg/L)													
105-67-9	2,4-Dimethylphenol	2.8 J	2.8 J	MW-04	1/14	10	2.8	NA	73	N	140	FDEP	No	BSL
91-57-6	2-Methylnaphthalene	20	20	MW-04	1/14	10	20	NA	12	N	20	FDEP	Yes	ASL
91-20-3	Naphthalene	1.7 J	31	MW-04	2/14	10	31	NA	0.65	N	20	FDEP	Yes	ASL
	Polynuclear Aromatic Hydrocarbons (µg/L)													
90-12-0	1-Methylnaphthalene	0.44 J	10	MW-04	2/14	2 - 2.1	10	NA	12 ⁽⁶⁾	N	20	FDEP	No	BSL
91-57-6	2-Methylnaphthalene	0.57 J	18	MW-04	3/14	2	18	NA	12		20	FDEP	Yes	ASL
193-39-5	Indeno(1,2,3-cd)pyrene	0.05 J	0.05 J	DPT-01	1/14	0.1	0.05	NA	0.092	C	0.2	FDEP	No	BSL
91-20-3	Naphthalene	0.69 J	30	MW-04	3/14	2	30	NA	0.65	N	20	FDEP	Yes	ASL
	Inorganics - Unfiltered (µg/L)													
7429-90-5	Aluminum	109 J	3190	MW-51-05	11/14	73.6	3190	147659	3700	N	200	FDEP	No	BKG
7440-36-0	Antimony	2.6 B	3.9 B	DPT-01	3/14	2.6	3.9	43	1.5	N	6	FDEP	No	BKG
7440-38-2	Arsenic	3.4 J	3.4 J	MW-51-06	1/14	2.7	3.4	13.2	0.045	C	50	FDEP	No	BKG
7440-39-3	Barium	26.6 J	126 J	MW-02	14/14	NA	126	616	260	N	2000	FDEP	No	BSL, BKG
7440-41-7	Beryllium	0.31 B	0.5 B	DPT-02	3/14	0.3 - 0.36	0.5	8.2	7.3	N	4	FDEP	No	BSL, BKG
7440-43-9	Cadmium	0.45 J	2.9	MW-06	4/14	0.2	2.9	8.2	1.8	N	5	FDEP	No	BKG
7440-70-2	Calcium	980 J	112000	MW-09I	14/14	NA	112000	59066	1055398 ⁽⁷⁾		NA	NA	No	BSL, NUT
7440-47-3	Chromium	2.8 J	3 J	MW-51-05	2/14	1.6	3	208	11 ⁽⁸⁾	N	100	FDEP	No	BSL, BKG
7440-48-4	Cobalt	0.91 J	2.2 J	MW-04	9/14	0.7 - 1.8	2.2	22.6	220	N	420	FDEP	No	BSL, BKG
7440-50-8	Copper	1.7 J	8 J	MW-04	7/14	1.1	8	40.4	150	N	1000	FDEP	No	BSL, BKG
7439-89-6	Iron	154	5560	DPT-04	14/14	NA	5560	68292	1100	N	300	FDEP	No	BKG
7439-92-1	Lead	1.8 J	4.2	MW-06	2/14	1.5	4.2	45.8	15 ⁽⁹⁾		15	FDEP	No	BSL, BKG

See notes at end of table.

Table 7-5 (Continued)
Occurrence, Distribution and Selection of Chemicals of Potential Concern
Direct Contact With Groundwater

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CAS Number	Chemical	Minimum ⁽¹⁾ Concentration	Maximum ⁽¹⁾ Concentration	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background ⁽²⁾ Value	Screen ⁽³⁾ Toxicity Value	Potential ⁽⁴⁾ ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for ⁽⁵⁾ Contaminant Deletion or Selection
Inorganics - Unfiltered (µg/L) (con't)													
7439-95-4	Magnesium	803 J	33300	MW-10D	14/14	NA	33300	19316	118807 ⁽⁷⁾	NA	NA	No	BSL, NUT
7439-96-5	Manganese	7.3 J	119	DPT-04	14/14	NA	119	204	73 N	50	FDEP	No	BKG
7440-02-0	Nickel	1.3 J	4.3 J	DPT-04	9/14	1.30	4.3	74.8	73 N	100	FDEP	No	BSL, BKG
7440-09-7	Potassium	521 J	7060	MW-05	14/14	NA	7060	9038	297016 ⁽⁷⁾	NA	NA	No	BSL,NUT,BKG
7440-23-5	Sodium	4470 J	19600	MW-51-06	14/14	NA	19600	24626	396022 ⁽⁷⁾	NA	NA	No	BSL,NUT,BKG
7440-62-2	Vanadium	0.51 J	6.5 J	MW-51-06	11/14	0.5	6.5	294	26 N	49	FDEP	No	BSL, BKG
7440-66-6	Zinc	3.8 J	24.3	MW-09I	14/14	NA	24.3	173.2	1100 N	5000	FDEP	No	BSL, BKG

Notes:

(1) Minimum/maximum detected concentration.

(2) Background value for inorganics is two times the mean background concentration.

(3) USEPA Region III RBC Table, April 13, 2000 Ingestion of Tap Water (Cancer benchmark value = 1E-06, HI = 0.1)

(4) GCTLs taken from Table I, FAC 62-777.

(5) Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions:

N/A = Not Applicable

SMCL = Secondary Maximum Contaminant Level

J = Estimated Value

C = Carcinogenic

N = Non-Carcinogenic

TT = Treatment technique.

(6) No value available, therefore value for 2-methylnaphthalene used based on similar chemical/toxicological characteristics.

(7) Essential nutrient screening level based on recommended dietary allowances (HLA, 1999).

(8) Value is for hexavalent chromium.

(9) Action Level, USEPA Drinking Water Standards and Health Advisories, Summer 2000.

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Direct Contact With Surface Water

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CAS Number	Chemical	Minimum ⁽¹⁾ Concentration	Maximum ⁽¹⁾ Concentration	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background ⁽²⁾ Value	Screening ⁽³⁾ Toxicity Value	Potential ⁽⁴⁾ ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection ⁽⁵⁾
Volatile Organic Compounds - µg/L													
78-93-3	2-Butanone	0.7 J	0.7 J	W005	1/3	10	0.7	NA	190 N	120000	FDEP	No	BSL
75-09-2	Methylene Chloride	0.65 J	0.71 J	W003	3/3	NA	0.71	NA	4.1 C	⁽⁶⁾	FDEP	No	BSL
108-88-3	Toluene	0.11 J	0.15 J	W005	2/3	1	0.15	NA	75 N	475	FDEP	No	BSL

Notes:

(1) Minimum/maximum detected concentration.

(2) No background surface water samples were collected.

(3) USEPA Region III Risk-Based Concentration Table, April 13, 2000. (Cancer benchmark value = 1E-06, HI = 0.1)

(4) Freshwater Surface Water Criteria, FDEP Chapter 62-777

(5) Rationale Codes Selection Reason: Above Screening Levels (ASL)
 Deletion Reason: No Toxicity Information (NTX)
 Essential Nutrient (NUT)
 Below Screening Level (BSL)

(6) Less than or equal to 5.67 ug/L (annual average) for Class I groundwater and less than or equal to 470.0 ug/L based on FDEP Chapter 62-302, Criteria for Surface Water Classifications, December 1996.

Definitions: N/A = Not Applicable

SMCL = Secondary Maximum Contaminant Level
 J = Estimated Value
 C = Carcinogenic
 N = Non-Carcinogenic

Table 7-7
Occurrence, Distribution, and Selection of Chemicals of Potential Concern
Direct Contact With Sediment

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CAS Number	Chemical	Minimum ⁽¹⁾ Concentration	Maximum ⁽¹⁾ Concentration	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background ⁽²⁾ Value	Screening ⁽³⁾ Toxicity Value	Potential ⁽⁴⁾ ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for ⁽⁵⁾ Contaminant Deletion or Selection
Volatile Organic Compounds - (µg/kg)													
78-93-3	2-Butanone	5.7 J	5.7 J	D004	1/3	5.4 - 19	5.7	NA	4700000 N	3100000	SCTL	No	BSL
108-88-3	Toluene	0.69 J	0.69 J	D004	1/3	4.7 - 5.4	0.69	NA	1600000 N	380000	SCTL	No	BSL

Notes:

- [illegible]

Definitions: N/A = Not Applicable
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

Table 7-8 presents a summary of the chemicals retained as COPCs in soil, groundwater, surface water, and sediment at PSC 51.

7.2 EXPOSURE ASSESSMENT

The exposure assessment defines and evaluates the exposures experienced by likely receptor populations at a site. In order to have an exposure, several factors must be present: (1) a source and mechanism of release; (2) a route of contaminant transport through an environmental medium; (3) a contact point for a human receptor; and (4) an exposure route at the point of contact. All four components must be present for the exposures to occur.

The exposure assessment presented in this section of the report consists of several subsections that characterize the physical site setting and the potential receptors of concern, identify the potential contaminant migration and exposure pathways, define the contaminant concentrations at the point of exposure, and present the equations used to quantify exposure in terms of contaminant intake (dose). Appendix J of this report contains sample calculations for the quantification of contaminant intakes, as well as the chemical-specific intakes for PSC 51.

7.2.1 Exposure Setting

NAS Jacksonville is located approximately nine miles south of downtown Jacksonville, Florida, in Duval County. Figure 2-1 presents the general site location and Figure 2-2 presents a site map. PSC 51 is located in the western portion of the south antenna field immediately north of the southern perimeter of NAS Jacksonville. PSC 51 consists of the ODA and the FFTA. The ODA is a nearly circular area located north of the patrol road, which runs along the base's southern boundary, and west of Allegheny Road. The FFTA is located approximately 250 ft northwest of the ODA.

PSC 51 is currently not used for any purpose. Most of the site is covered with grass and no buildings are located on the site. The site is fenced in and access is limited to base personnel. At the present time, there are no definite plans for the future use of the site.

Groundwater at NAS Jacksonville is not used for any purpose. No potable wells are used at the base and the base is supplied by public water. It has been reported that the residential area adjacent to the southern perimeter of the base (downgradient) relies on groundwater from the Floridan deep aquifer as a potable water source.

Table 7-8
Chemicals Retained as COPCs for Quantitative Evaluation
In Human Health Risk Assessment - PSC 51

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Chemical	Surface Soil			Groundwater	Surface Water	Sediment
	Direct Contact	Soil to Air	Soil to Groundwater			
Volatile Organic Compounds						
1,1-DCE				X		
1,2-Dichloroethane				X		
1,2-DCE (total)				X		
Benzene				X		
Bromodichloromethane				X		
Chloroform				X		
TCE				X		
Vinyl chloride				X		
Semivolatile Organic Compounds/PAH						
2-Methylnaphthalene				X		
Naphthalene				X		
Inorganics						
Arsenic	X					
Iron	X					
Notes:						
X indicates that chemical is retained as a COPC.						

Surface water (an unnamed stream) is located adjacent and to the south of the NAS Jacksonville southern property line and approximately 200 ft south of the PSC 51. The groundwater flow appears to intersect the local surface water drainage system. Run-off from other areas on base flow through storm sewers and into this surface drainage system. The surface drainage system flows south with the direction of groundwater flow. The surface water in the vicinity of the site is not deep enough to support fishing or swimming and these activities have not been observed at this stream.

7.2.2 Conceptual Site Model

This section discusses the conceptual site model for PSC 51. A conceptual site model facilitates consistent and comprehensive evaluation of the potential risks to human health by creating a framework for identifying the pathways by which human receptors may come in contact with contaminated media resulting from the source area. A conceptual site model depicts the relationships between the following elements, which are necessary for defining complete exposure pathways:

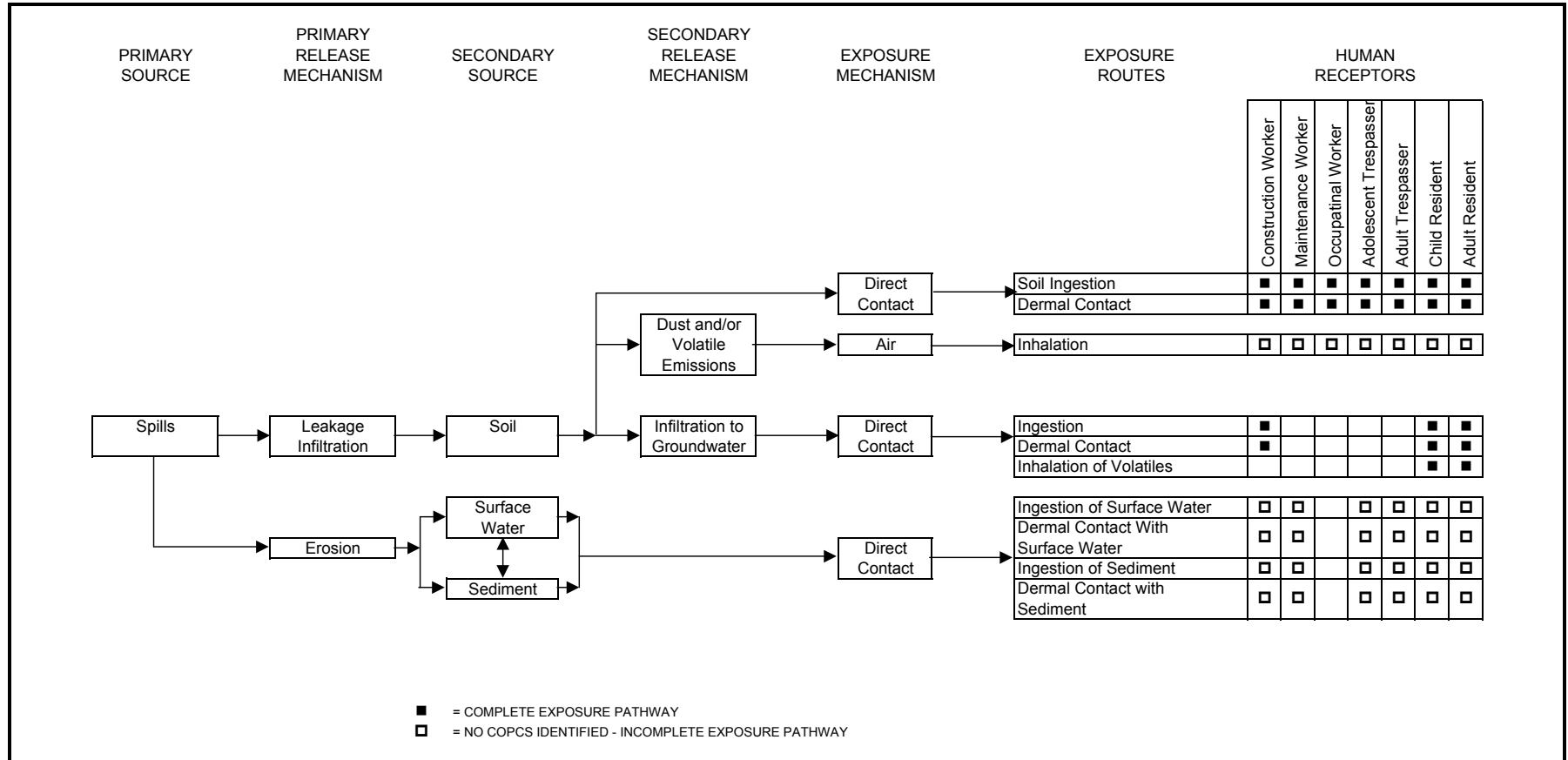
- Site sources of contamination
- COPCs in environmental media
- Contaminant release mechanisms
- Contaminant transport pathways
- Exposure mechanisms and exposure routes
- Potential receptors

The conceptual site model for PSC 51 is provided in Figure 7-2. The potential sources of contamination at PSC 51 were releases to surface soil and groundwater from past operations at the ODA and FFTA. Contaminants may be released from the site by mechanisms such as storm water runoff and subsequent erosion of surface soil, leaching of COPCs from soil via infiltrating water to subsurface soil and subsequent migration through the subsurface soil to the water table, wind erosion of surface soil (fugitive dust), and the volatilization of chemicals from soil (volatile emissions).

Storms generate runoff, which is directed toward the surrounding surface water. Initially, this water may move across the site as sheet flow, which can entrain loose soil material. This soil is moved from the site as a sediment and will be deposited where the flow velocity diminishes below that needed to carry a particular grain size.

**FIGURE 7-2
CONCEPTUAL SITE MODEL
PSC 51**

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida



Soluble chemicals may also migrate downward through the soil column via infiltrating precipitation. The migration of these chemicals may be somewhat impeded by the chemical's tendency to bind to soil organic material. However, these soluble chemicals may eventually reach the water table. Once in the groundwater, these chemicals continue to migrate via dispersion and advection.

Chemicals adsorbed to surface soil may also be released from a site via wind erosion of loose soil material. These particulates are carried downwind and potentially off-site if the grain size is small enough and the wind velocity is great enough. Additionally, chemicals may also be released from soil via volatilization.

Once released from the source, contaminants are transported in media such as soil, groundwater, surface water, sediment, or air. Potential receptors may be exposed either directly or indirectly to contaminants in these media by a variety of exposure mechanisms, such as direct contact and immersion. Typically, several exposure routes (ingestion, dermal contact, inhalation, etc.) are associated with a particular exposure mechanism.

The conceptual site model presented in Figure 7-2 also indicates those exposure routes that are carried through the quantitative risk assessment for each potential receptor. An objective of the development of the conceptual site model, as well as the baseline HHRA, is to focus attention on those pathways that contribute the most to the potential impacts on human health and the environment and to provide the rationale for eliminating other exposure pathways that are considered to be minor components of the overall risk.

7.2.3 Potential Exposure Pathways

Potential receptors can come into contact with contaminants in a variety of ways, which are generally the result of interactions between a receptor's behavior or lifestyle and an exposure medium. This assessment defines an exposure route as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.

7.2.3.1 Air

This pathway is based on the scenario that a receptor is immersed in air that contains suspended particulates and/or volatile organic vapors originating from the source area. Subsequent exposure of the receptor occurs upon inhalation of the ambient air.

A qualitative comparison of maximum detected concentrations in surface soil at PSC 51 to USEPA SSLs based on intermedia transfer (from soil to air) was performed to determine if additional quantitative

analysis of this potential exposure pathway was warranted. The SSLs are based on residential land use and lifetime exposure scenarios and are, therefore, conservative values for potential receptors under current and future land use conditions. Exposures to fugitive dust released from soil were found to be relatively insignificant, based on the qualitative screening. This screening is summarized in Table 7-3. Maximum detections of all chemicals in surface soil were less than the SSLs; therefore, exposure via the inhalation pathway is considered to be minimal and was not considered for further evaluation.

7.2.3.2 Direct Contact with Soil and Sediment

Potential receptors may come into direct contact with surface soil and sediment, which may be affected by the release of chemicals from the source area. During the receptor's period of contact, the individual may be exposed via incidental ingestion of surface soil and sediment or via dermal absorption of contaminants from surface soil and sediment.

Dermal contact with chemicals detected in the site surface soil and sediment may or may not result in a significant exposure. In general, inorganics, which were detected frequently in the soil/sediment samples and were selected as COPCs, tend to strongly adhere to organic matter. For these chemicals to be percutaneously absorbed, they must first desorb from soil and diffuse through the skin. Various factors affect the rate of dermal absorption, including the amount of soil on the skin surface, soil characteristics (moisture, pH, organic carbon content, etc.), skin characteristics (thickness, temperature, hydration, etc.), volatilization losses, and chemical-specific properties. Dermal exposures to chemicals in soil are evaluated quantitatively in the baseline risk assessment. No COPCs were identified for sediment; therefore, this medium is not further evaluated in the baseline risk assessment.

7.2.3.3 Direct Contact with Groundwater

Human receptors using groundwater as a potable water supply may be exposed to groundwater via ingestion, dermal contact, and inhalation. Shallow groundwater is not used as a potable water supply in the vicinity of the site nor is it likely to be used as a potable source due to poor quality and low yield. The residential area adjacent to the southern perimeter of the base (downgradient) relies on deep groundwater as a potable water source. It has been reported that these wells are at depths of 200 ft or greater. There is a confining layer between the surficial zone and deeper zones; therefore, it is unlikely that contamination from the surficial zone will migrate to the deeper zones. Assessment data indicated limited impact at depth within the shallow aquifer that supports this conceptual model. Construction workers may have dermal contact with groundwater if excavation below the water table occurs.

7.2.3.4 Direct Contact with Surface Water

Receptors may come into direct contact with surface water in the unnamed stream. The surface water may contain contaminants in a particular dissolved phase. Individuals may be exposed via dermal contact and/or incidental ingestion. No COPCs were identified for surface water, therefore, this medium is not further evaluated in the baseline risk assessment.

7.2.3.5 Potential Receptors

Potential receptors were identified for both current and future land use conditions. The receptors were identified by analyzing the interaction of current land use practices and the identified sources of contamination. Future site use is expected to remain the same as current. As discussed above, no COPCs were identified for sediment and surface water therefore these media are not evaluated further in this risk assessment. The identified receptors are as follows:

- **Future construction workers** who may contact contaminated media while excavating or performing construction activities. Media include surface soil and groundwater. Evaluated exposure pathways are incidental ingestion and dermal contact with COPCs in soil and groundwater.
- **Current/future maintenance workers (groundskeepers)** who may contact contaminated surface soil while performing assigned duties. Evaluated exposure pathways are incidental ingestion and dermal contact with COPCs in surface soil.
- **Future occupational (commercial/industrial) workers** who may contact contaminated surface soil media while performing work tasks. Evaluated exposure pathways are incidental ingestion and dermal contact with COPCs in surface soil. This receptor population is only considered for future conditions because the site is currently not used for any purpose. Exposure incurred by future commercial/industrial workers would be dependent on work tasks. Office workers may be minimally exposed to site-related contamination when compared to outdoor workers.
- **Current/future adult and adolescent trespassers** who may contact contaminated surface soil. Trespassers are not a likely receptor under current conditions since a fence surrounds PSC 51 and access to NAS Jacksonville is restricted. Evaluated exposure pathways are incidental ingestion and dermal contact with COPCs in surface soil.

- **Hypothetical future on-site residents** are evaluated as potential receptors. Future child and adult residents are not receptors under current or expected future land use and are included only to provide an indication of potential risks if the area was developed for residential use. Hypothetical future on-site residents may be exposed to contaminated surface soil and groundwater. Anticipated exposure pathways are incidental ingestion of/dermal contact with COPCs in surface soil and exposure to COPCs in groundwater via the ingestion, dermal contact, and inhalation (i.e., inhalation of volatile organic chemicals during showering) routes of exposure.

A summary of the rationale used for the selection or elimination of a potential receptor group is provided in Table 7-9. Recreational users are not considered to be a potential receptor group because the site is not currently used for recreational activities nor is it expected to be used for recreational activities in the future. If an individual did use the site for recreational activities, their exposures would be similar to those of the adolescent and adult trespassers.

7.2.3.6 Exposure Point Concentrations

According to USEPA guidance (1989, 1992b), risk assessments are conducted using a representative exposure point concentration for each COPC. The exposure point concentration is typically defined as the upper 95 percent confidence limit (UCL), which is based on the distribution of a data set. However, when small data sets (i.e., less than 11 samples) are available for a site and/or medium, the UCL is not considered to be a good estimate of the sample mean and in those cases the maximum detected concentration is used as the exposure point concentration (EPC).

Only four surface soil samples were collected, consequently the maximum detected concentration in surface soil samples was used as the EPC. The *Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment* (USEPA, 1991) was followed to determine the EPC for COPs in groundwater. The guidance recommends that the groundwater exposure point concentration is equal to the arithmetic average of the wells in the highly concentrated area of the plume. A discernable groundwater plume could not be defined, consequently, the mean of the detected concentrations was used as the exposure point concentrations for groundwater.

Exposure point concentrations for COPCs for surface soil and groundwater are summarized in Table 7-10. The exposure point concentrations are also presented in the Risk Assessment Guidance for Superfund (RAGS) Part D tables included in Appendix J.

Table 7-9
Conceptual Site Model and Selection of Exposure Pathways
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Surface Soil	Surface Soil	Entire Site	Site Maintenance Workers	Ingestion	Quant(1)	Site maintenance workers, such as groundskeepers, may periodically enter the site and contact contaminated soil in the course of their job duties.
					Dermal	Quant(1)	Site maintenance workers, such as groundskeepers, may periodically enter the site and contact contaminated soil in the course of their job duties.
				Trespassers	Ingestion	Quant	Persons may trespass on the site and contact contaminated soil.
					Dermal	Quant	Persons may trespass on the site and contact contaminated soil.
		Air	Vapors and Particulates in Air - Entire Site	Site Maintenance Workers and Trespassers	Inhalation	None	No COPCs were identified for the inhalation pathway.
	Groundwater	Groundwater/Air	Surficial Aquifer/Vapors	Site Maintenance Workers and Trespassers	Ingestion	None	Direct contact with groundwater does not occur under current or future land use. Shallow groundwater is not used as a domestic water supply.
					Dermal	None	Direct contact with groundwater does not occur under current or future land use. Shallow groundwater is not used as a domestic water supply.
					Inhalation	None	Direct contact with groundwater does not occur under current or future land use. Shallow groundwater is not used as a domestic water supply.
	Surface Water	Surface Water	Stream Located South of the ODA	Site Maintenance Workers	Ingestion	None	Site maintenance workers, such as groundskeepers, may periodically enter the site and contact contaminated surface water in the course of their job duties. No COPCs were identified in surface water, therefore this pathway is not evaluated.
					Dermal	None	Site maintenance workers, such as groundskeepers, may periodically enter the site and contact contaminated surface water in the course of their job duties. No COPCs were identified in surface water, therefore this pathway is not evaluated.

Table 7-9 (Continued)
Conceptual Site Model and Selection of Exposure Pathways
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future (con't)	Surface Water (con't)	Surface Water	Stream Located South of the ODA	Trespassers	Ingestion	None	Persons may trespass on the site and contact contaminated surface water. No COPCs were identified in surface water, therefore this pathway is not evaluated.
					Dermal	None	Persons may trespass on the site and contact contaminated surface water. No COPCs were identified in surface water, therefore this pathway is not evaluated.
		Air	Vapors from Stream Located South of the ODA	Site Maintenance Workers and Trespassers	Inhalation	None	Inhalation is expected to represent a relatively minor exposure compared to the dermal and ingestion pathways.
	Sediment	Sediment	Stream Located South of the ODA	Site Maintenance Workers	Ingestion	None	Site maintenance workers, such as groundskeepers, may periodically enter the site and contact contaminated sediment in the course of their job duties. No COPCs were identified in sediment, therefore this pathway is not evaluated.
					Dermal	None	Site maintenance workers, such as groundskeepers, may periodically enter the site and contact contaminated sediment in the course of their job duties. No COPCs were identified in sediment, therefore this pathway is not evaluated.
				Trespassers	Ingestion	None	Persons may trespass on the site and contact contaminated sediment. No COPCs were identified in sediment, therefore this pathway is not evaluated.
					Dermal	None	Persons may trespass on the site and contact contaminated sediment. No COPCs were identified in sediment, therefore this pathway is not evaluated.
Future	Surface/ Subsurface Soil	Surface/ Subsurface Soil	Entire Site	Excavation/ Construction Workers	Ingestion	Quant	Excavation/construction activities may occur at the site and workers may be exposed to contaminated soil.
					Dermal	Quant	Excavation/construction activities may occur at the site and workers may be exposed to contaminated soil.
		Air	Vapors and Particulates in Air - Entire Site	Excavation/ Construction Workers	Inhalation	None	No COPCs were identified for the inhalation pathway.
	Surface Soil	Surface Soil	Entire Site	Occupational Workers	Ingestion	Quant	Occupational (commercial/industrial) workers, may contact contaminated soil in the course of their job duties.
					Dermal	Quant	Occupational (commercial/industrial) workers, may contact contaminated soil in the course of their job duties.

Table 7-9 (Continued)
Conceptual Site Model and Selection of Exposure Pathways
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future (con't)	Surface Soil (con't)	Surface Soil	Entire Site	Residents	Ingestion	Quant	Hypothetical on-site residents may be exposed to contaminated soil during typical residential activities, such as gardening or playing.
					Dermal	Quant	Hypothetical on-site residents may be exposed to contaminated soil during typical residential activities, such as gardening or playing.
		Air	Vapors and Particulates in Air - Entire Site	Occupational Workers and Residents	Inhalation	None	No COPCs were identified for the inhalation pathway.
	Groundwater	Groundwater	Surficial Aquifer	Excavation/Construction Workers	Ingestion	Quant	Excavation/construction activities may occur at the site and workers may be exposed to contaminated groundwater.
					Dermal	Quant	Excavation/construction activities may occur at the site and workers may be exposed to contaminated groundwater.
				Residents	Ingestion	Quant	Hypothetical on-site residents may be exposed to contaminated groundwater during typical residential activities.
					Dermal	Quant	Hypothetical on-site residents may be exposed to contaminated groundwater during typical residential activities.
				Occupational Workers	Ingestion Dermal	None None	There are no drinking water wells on-site. Occupational workers are not likely to contact groundwater.
		Air	Vapors	Excavation/Construction Workers	Inhalation	None	Inhalation is expected to represent a relatively minor exposure compared to the dermal and ingestion pathways.
				Residents	Inhalation	Quant	Hypothetical on-site residents may be exposed to VOCs while showering or bathing.
	Surface Water	Surface Water	Stream Located South of the ODA	Occupational and Excavation/Construction Workers	Ingestion	None	Workers may contact contaminated surface water in the course of their job duties. No COPCs were identified in surface water, therefore this pathway is not evaluated.
					Dermal	None	Workers may contact contaminated surface water in the course of their job duties. No COPCs were identified in surface water, therefore this pathway is not evaluated.

Table 7-9 (Continued)
Conceptual Site Model and Selection of Exposure Pathways
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Table 7-9 (Continued)
Conceptual Site Model and Selection of Exposure Pathways
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future (con't)				Residents	Ingestion	None	Hypothetical future on-site residents may be exposed to contaminated surface water. No COPCs were identified in surface water, therefore this pathway is not evaluated. Hypothetical future on-site residents may be exposed to contaminated surface water. No COPCs were identified in surface water, therefore this pathway is not evaluated.
					Dermal	None	
		Air	Vapors from Stream Located South of the ODA	Occupational Workers, Excavation/Construction Workers and Residents	Inhalation	None	Inhalation is expected to represent a relatively minor exposure compared to the dermal and ingestion pathways.
	Sediment	Sediment	Stream Located South of the ODA	Occupational and Excavation/Construction Workers	Ingestion	None	Workers may contact contaminated sediment in the course of their job duties. No COPCs were identified in sediment, therefore this pathway is not evaluated.
					Dermal	None	Workers may contact contaminated sediment in the course of their job duties. No COPCs were identified in sediment, therefore this pathway is not evaluated.
				Residents	Ingestion	None	Hypothetical future on-site residents may be exposed to contaminated sediment. No COPCs were identified in sediment, therefore this pathway is not evaluated.
	Dermal	None	Hypothetical future on-site residents may be exposed to contaminated sediment. No COPCs were identified in sediment, therefore this pathway is not evaluated.				

Footnotes:

- 1 Quantitative.
2 Qualitative.

Table 7-10
Exposure Point Concentrations
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Chemical	Surface Soil (1) (mg/kg)	Groundwater (2) (µg/L)
Volatile Organic Compounds		
1,1-DCE	NA	0.520
1,2-Dichloroethane	NA	0.330
1,2-DCE (total)	NA	12.1
Benzene	NA	18.7
Bromodichloromethane	NA	0.260
Chloroform	NA	1.13
TCE	NA	1.30
Vinyl chloride	NA	2.30
Semivolatile Organic Compounds		
2-Methylnaphthalene	NA	6.49
Naphthalene	NA	10.7
Inorganics		
Arsenic	3.7	NA
Iron	9620	NA
Notes: (1) - Maximum concentration. (2) - Average concentration of detected concentrations. RAGS Part D Tables are included in Appendix G. NA = not applicable		

7.2.4 Quantification of Exposure

Estimates of exposure are based on the contaminant concentrations at the exposure points and on scenario-specific assumptions and intake parameters. The models and equations used to quantify intakes are described in this section and have been obtained from a variety of USEPA guidance documents, which are cited in the specific intake estimation sections that follow.

Exposure model parameters for all receptors are presented in Table 7-11. The parameters are based on those presented in the *Remedial Investigation/Feasibility Study Field Sampling Plan for Potential Source of Contamination 51* (TtNUS, 1999a) and standard USEPA Region IV default values. The parameters are used in the equations presented in this section, along with the exposure point concentrations previously defined to estimate contaminant intakes, which will be used to determine potential risks. Individual chemical intakes for each receptor/exposure route combination are presented in Appendix J.

Incidental Ingestion of Soil

The incidental ingestion of a small amount of soil is assumed to occur when a receptor comes into direct contact with contaminated soil. Exposure associated with the oral route of exposure is estimated in the following manner (USEPA, 1989):

$$\text{Intake}_{\text{si}} = \frac{(C_{\text{si}})(\text{IR}_{\text{s}})(\text{FI})(\text{EF})(\text{ED})(\text{CF})}{(\text{BW})(\text{AT})}$$

where: Intake_i = intake of contaminant "i" from soil (mg/kg/day)
C_{si} = concentration of contaminant "i" in soil (mg/kg)
IR_s = incidental ingestion rate for soil (mg/day)
FI = fraction ingested from contaminated source (decimal fraction)
EF = exposure frequency (days/year)
ED = exposure duration (years)
CF = conversion factor (10⁻⁶ kg/mg)
BW = body weight (kg)
AT = averaging time (days);
for noncarcinogens, AT = ED x 365 days/year;
for carcinogens, AT = 70 years x 365 days/year

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

See notes at end of table.

Table 7-11 (Continued)
Summary of Exposure Input Parameters
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

DEFINITIONS

$C_{\text{soil/gw}}$	Exposure concentration for soil/sediment/groundwater/surface water.
UCL	95% Upper Confidence Limit, used if the data set is greater than 10 samples.
NA	Not Applicable. Receptor/pathway not evaluated.
t^*	Time it takes to reach steady-state conditions.
T	Lag time
B	Bunge Model partitioning coefficient

FOOTNOTES

- A Assumption, based on professional judgement
- 1 USEPA 1991. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Parameters*
- 2 USEPA Region 4 1995. *Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment*
- 3 USEPA 1989. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Interim Final)* EPA/540/1-89/002
- 4 USEPA 1992b. *Dermal Exposure Assessment: Principles and Applications* EPA/600/8-91/011 B
- 5 USEPA 1997. *Exposure Factors Handbook* EPA/600/p-95/002 Fa

Since PSC 51 is relatively small in size it was assumed that a construction worker would be engaged in construction related activities 90 days/year (EF_{Soil}) over a 1 year period (ED). Maintenance workers are assumed to be exposed 30 days a year over 25 years. Adolescent trespassers are assumed to be exposed 100 days a year over 10 years. Adult trespassers are assumed to be exposed 45 days a year over 20 years. All other exposure parameters for incidental ingestion of soil are standard USEPA default values.

Dermal Contact with Soil

During direct contact, contaminated soil may adhere to the skin of potential receptors. Dermal absorption of COPCs from potentially contaminated soil and sediment is calculated using the following equation:

$$\text{Intake}_{\text{si}} = \frac{(C_{\text{si}})(SA)(AF)(ABS)(CF)(EF)(ED)}{(BW)(AT)}$$

where: $\text{Intake}_{\text{si}}$ = amount of chemical "i" absorbed during contact with soil or sediment (mg/kg/day)

C_{si} = concentration of chemical "i" in soil or sediment (mg/kg)

SA = skin surface area available for contact (cm^2/day)

AF = skin adherence factor [milligrams per square centimeter (mg/cm^2)]

ABS = absorption factor (decimal fraction)

CF = conversion factor (10^{-6} kg/mg)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight (kg)

AT = averaging time (days);

for noncarcinogens, $AT = ED \times 365 \text{ days/year}$;

for carcinogens, $AT = 70 \text{ years} \times 365 \text{ days/year}$

The same exposure frequencies and durations used in the estimation of incidental ingestion intakes of soil/sediment are used to estimate exposure via dermal contact. Current guidance (USEPA, 1992b) is used to develop the following default assumptions concerning the amount of skin surface area available for contact for a receptor:

- For the construction worker, maintenance worker, adult trespasser, and adult resident the surface area assumed to be available for soil contact ($5,300 \text{ cm}^2$) is the arithmetic mean skin surfacer area value for the head, hands, forearms, and lower legs.

- For the occupational worker, the surface area assumed to be available for soil contact (2,000 cm²) is the arithmetic mean value for the head and hands.
- For the adolescent trespasser, the surface area assumed to be available for soil contact (3,820 cm²) which assumes that 25 percent of the total body surface is available for exposure.
- For hypothetical future on-site child resident, the surface area assumed to be available for soil contact (2,900 cm²) is the arithmetic mean value for the head, hands, forearms, lower legs, and feet.

A value of 1.0 mg/cm² was used for the skin adherence factors for all receptors (USEPA Region IV, 1995). Region IV default values of 0.01 for organics and 0.001 for inorganics were used for the absorption factors (ABS) (USEPA Region IV, 1995a).

Ingestion of Groundwater

Ingestion of groundwater will be evaluated for the hypothetical future resident only. Incidental ingestion of groundwater will be evaluated for the construction worker. Intakes associated with ingestion of groundwater or surface water are evaluated using the following equations (USEPA, 1989):

$$\text{Intake}_{wi} = \frac{(C_{wi})(IR_w)(EF)(ED)}{(BW)(AT)} \quad \text{for groundwater}$$

where: Intake_{wi} = intake of chemical "i" from water (mg/kg/day)
 C_{wi} = concentration of chemical "i" in water (mg/L)
 IR_w = ingestion rate for groundwater (L/day)
 EF = exposure frequency (days/yr)
 ED = exposure duration (yr)
 BW = body weight (kg)
 AT = averaging time (days);
 for noncarcinogens, AT = ED x 365 days/yr;
 for carcinogens, AT = 70 yr x 365 days/yr

USEPA default exposure assumptions are used to evaluate exposure to groundwater by hypothetical future child and adult residents. An incidental groundwater ingestion rate of 10 ml/hour was used for construction workers (USEPA Region IV, 1995a). It was assumed that the construction worker would be exposed to groundwater one hour a day. The same exposure frequencies and exposure duration that were used for a construction worker exposed to soil were used for exposure to groundwater.

Dermal Contact with Groundwater

The following equation is used to assess exposures resulting from dermal contact with water (USEPA,

$$1992b): DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(A)}{(BW)(AT)}$$

where: DAD_{wi} = dermally absorbed dose of chemical "i" from water (mg/kg/day)
 DA_{event} = absorbed dose per event (mg/cm²-event)
 EV = event frequency (events/day)
 ED = exposure duration (yr)
 EF = exposure frequency (days/yr)
 A = skin surface area available for contact (cm²)
 BW = body weight (kg)
 AT = averaging time (days);
for noncarcinogens, $AT = ED \times 365$ days/yr;
for carcinogens, $AT = 70 \text{ yr} \times 365$ days/yr

Total body exposure (e.g., showering) is assumed for residents dermally exposed to COPCs in groundwater. For dermal exposure to groundwater by construction workers, the surface area assumed to be available for contact is 5,000 cm², which is the arithmetic mean value for the hands, forearms, and lower legs. It was assumed that a construction worker was exposed to groundwater one hour a day. USEPA default values were used for a child and adult residents. The total body surface area was assumed to be available for contact to groundwater by a child (6,600 cm²) and adult resident (20,000 cm²). Exposure frequencies and duration's for dermal contact with groundwater are assumed to be the same as those for ingestion of groundwater.

The absorbed dose per event (DA_{event}) is estimated using a nonsteady-state approach for organic compounds and a traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} < t^*, \text{ then: } DA_{event} = (2 K_p)(C_{wi})(CF) \left[\frac{\sqrt{6 \tau t_{event}}}{\pi} \right]$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (K_p)(C_{wi})(CF) \left[\frac{t_{event}}{1+B} + 2 \tau \left[\frac{1+3B}{1+B} \right] \right]$$

where: t_{event}	=	duration of event (hr/event)
t^*	=	time it takes to reach steady-state conditions (hr)
K_p	=	permeability coefficient from water through skin (cm/hr)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
τ	=	lag time (hr)
π	=	constant (dimensionless; equal to 3.141592654)
CF	=	conversion factor (0.001 L/cm ³)
B	=	partitioning constant derived by Bunge Model (dimensionless)

Values for the chemical-specific parameters (t_{event} , t^* , K_p , τ , and B) are obtained from the current dermal guidance (USEPA, 1992b, Table 5-8) and are presented in Table 7-12.

The following nonsteady-state equation is used to estimate DA_{event} for inorganics:

$$DA_{\text{event}} = (K_p) (C_{wi}) (t_{\text{event}})$$

In general, the recommended default value of 0.001 is used for the dermal permeability of inorganic constituents.

Inhalation of Volatiles in Groundwater

Groundwater exposure may also result in inhalation of volatiles, typically for adult residential receptors who may be exposed while showering, bathing, washing dishes, etc. Future adult residents exposed through inhalation while showering will be evaluated following USEPA Region IV guidance. USEPA Region IV Human Health Risk Assessment Guidance stipulates that the risk associated with inhalation of volatile COPCs while showering is equivalent to risk from exposure via ingestion of two liters of contaminated water per day. In order to calculate total risk from groundwater in accordance with USEPA Region IV guidance, the estimated risk calculated for ingestion of volatile organic COPCs in groundwater is doubled to factor in the risk from inhalation of volatile organic COPCs in groundwater.

7.3 TOXICITY ASSESSMENT

The toxicity assessment examines information concerning the potential human health effects associated with exposure to COPCs. The goal of the toxicity assessment is to provide, for each COPC, a

TABLE 7-12
Parameters for Evaluation of Dermal Contact With Groundwater
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Chemical	Estimated Kp (cm/hr)	tau-event (hr)	B	t* (hr)
Volatile Organic Compounds				
1,1-DCE	1.6E-02	3.4E-01	1.3E-02	6.0E-09
1,2-Dichloroethane	5.3E-03	3.5E-01	3.0E-03	1.3E-09
1,2-DCE (Total)	1.0E-02	3.4E-01	7.2E-03	8.7E-08
Benzene	2.1E-02	2.6E-01	1.3E-02	2.5E-07
Bromodichloromethane	5.8E-03	8.7E-01	1.2E-02	1.7E-09
Chloroform	8.9E-03	4.7E-01	9.3E-03	8.5E-09
TCE	1.6E-02	5.5E-01	2.6E-02	1.9E-08
Vinyl chloride	7.3E-03	2.1E-01	2.3E-03	9.5E-09
Semivolatile Organic Compounds				
2-Methylnaphthalene	1.4E-01	6.4E-01	7.2E-01	4.9E+00
Naphthalene	6.9E-02	5.3E-01	2.0E-01	2.2E+00
Notes: NA - Not applicable for inorganics. Source: USEPA, 1992: Dermal Exposure Assessment: Principles and Applications. USEPA/600/8-91/011B.				

quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects. The toxicity values presented in this section are integrated with the outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects.

The toxicological evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. This review of the data ideally determines both the nature of the health effects associated with a particular chemical, and the probability that a given quantity of a chemical could result in the referenced effect. This analysis defines the relationship between the dose received and the incidence of an adverse effect for the COPC.

The entire toxicological database is used to guide the derivation of cancer slope factors (CSFs) for carcinogenic effects and reference doses (RfDs) for noncarcinogenic effects. This data may include epidemiological studies, long-term animal bioassays, short-term tests, and evaluations based on molecular structure. Data from these sources are reviewed to determine if a chemical is likely to be toxic to humans. Because of the lack of available human studies, however, the majority of toxicity data used to derive CSFs and RfDs comes from animal studies.

For noncarcinogenic effects, the most appropriate animal model (i.e., the species most biologically similar to the human) is identified. Pharmacokinetic data often enter into this determination. In the absence of sufficient data to identify the most appropriate animal model, the most sensitive species is chosen. The RfD is generally derived from the most comprehensive toxicology study that characterizes the dose-response relationship for the critical effect of the chemical. Preference is given to studies using the exposure route of concern. In the absence of such data, however, an RfD for one route of exposure may be extrapolated from data from a study that used a different route of exposure. Such extrapolation must take into account pharmacokinetic and toxicological differences between the routes of exposure. Uncertainty factors are applied to the highest no-observed-adverse-effect-level (NOAEL) to adjust for inter- and intraspecies variation, deficiencies in the toxicological data base, and use of subchronic rather than chronic animal studies. Additional uncertainty factors may be applied to estimate a NOAEL from a lowest-observed-adverse-effect-level (LOAEL) if the key study failed to determine a NOAEL.

CSFs for weights-of-evidence of Group A or B chemicals are generally derived from positive cancer studies that adequately identify the target organ in the test animal data and characterize the dose-response relationship. CSFs are derived for Group C compounds for which the data are sufficient, but are not derived for Group D or E chemicals. No consideration is given to similarity in the animal and human target organ(s) because a chemical capable of inducing cancer in any animal tissue is considered potentially carcinogenic to humans. Preference is given to studies using the route of exposure of

concern, in which normal physiologic function was not impaired, and in which exposure occurred during most of the animal's lifetime. Exposure and pharmacokinetic considerations are used to estimate equivalent human doses for computation of the CSF. When a number of studies of similar quality are available, the data may be combined in the derivation of the CSF.

7.3.1 **Carcinogenic Effects**

The toxicity information considered in the assessment of potential carcinogenic risks includes a weight-of-evidence classification and a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of the available data from human and animal studies. A chemical may be placed in one of five groups in USEPA's classification system to denote its potential for carcinogenic effects:

- Group A - Known human carcinogen
- Group B1 or B2 - Probable human carcinogen
- Group C - Possible human carcinogen
- Group D - Chemicals that cannot be classified as a human carcinogen because of a lack of data
- Group E - Chemicals for which there is evidence of noncarcinogenicity in humans are in Group E.

The CSF is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing chemicals. It is defined as the upper bound estimate of the probability of cancer incidence per unit dose averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and/or laboratory animals, and are typically calculated for compounds in Groups A, B1, and B2, although some Group C carcinogens also have slope factors and some B2 carcinogens have none (e.g., lead). Slope factors are specific to a chemical and route of exposure and are expressed in units of $(\text{mg/kg/day})^{-1}$ for both oral and inhalation routes.

CSFs for COPCs at PSC 51 are presented in Table 7-13. The primary sources of information for these values are the USEPA's Integrated Risk Information System (IRIS)(USEPA, 2000b). The USEPA intends that IRIS supersede all other sources of toxicity information for risk assessment. If values are not available in IRIS, the annual Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a) are consulted. USEPA Region III Risk-Based Concentration Tables (April 13, 2000) are also used as a quick tabulated reference for available CSFs.

CSFs also exist for several (but not all) Class C compounds, which are identified as "possible" human carcinogens. These compounds typically exhibit inadequate evidence of carcinogenicity in humans and

Table 7-13
Cancer Toxicity Data - Oral/Dermal
PSC 51

Remedial Investigation/Feasibility Study
Naval Air Station Jacksonville
Jacksonville, Florida

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Cancer Slope Factor (2)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (3) (MM/DD/YYYY)
Volatile Organic Compounds							
1,1-DCE	6.0E-01	100%	6.0E-01	(mg/kg/day) -1	C	IRIS	05/15/00
1,2-Dichloroethane	9.1E-02	100%	9.1E-02	(mg/kg/day) -1	B2	IRIS	05/15/00
1,2-DCE (total)	NA	100%	NA	NA	NA	NA	NA
Benzene	5.5E-02	97%	5.7E-02	(mg/kg/day) -1	A	IRIS	05/15/00
Bromodichloromethane	6.2E-02	98%	6.3E-02	(mg/kg/day) -1	B2	IRIS	05/15/00
Chloroform	6.1E-03	20%	3.1E-02	(mg/kg/day) -1	B2	IRIS	05/15/00
TCE	1.1E-02	15%	7.3E-02	(mg/kg/day) -1	B2	USEPA III	04/13/00
Vinyl chloride	1.9E+00	100%	1.9E+00	(mg/kg/day) -1	A	HEAST	07/97
Semivolatile Organic Compounds							
2-Methylnaphthalene	NA	80%	NA	NA	NA	NA	NA
Naphthalene	NA	80%	NA	NA	C	NA	NA
Inorganics							
Arsenic	1.5E+00	41%	3.7E+00	(mg/kg/day) -1	A	IRIS	05/15/00
Iron	NA	15%	NA	NA	N/A	N/A	N/A
Notes:							
HEAST= Health Effects Assessment Summary Tables				USEPA Group:			
NA = not applicable				A - Human carcinogen			
(1) - USEPA Region IV, February 26, 1996.				B1 - Probable human carcinogen - indicates that limited human data are available			
(2) - CSF/dermal = CSF/oral/Oral to Dermal Adjustment Factor.				B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans			
(3) - For IRIS values, the date IRIS was searched.				C - Possible human carcinogen			
For HEAST values, the date of HEAST.				D - Not classifiable as a human carcinogen			
				E - Evidence of noncarcinogenicity			

limited evidence in animals. In this HHRA, Class C compounds are evaluated the same as Class A, B1, and B2 compounds. The uncertainty associated with this approach is discussed in Section 7.5.

Dermal CSFs are derived from the corresponding oral values. Regional guidance (USEPA Region IV, 1995, 1996b) is used as a basis for determining the dermal CSFs. In the derivation of a dermal CSF, the oral CSF is divided by the gastrointestinal absorption efficiency to determine a CSF based on an absorbed dose rather than an administered dose as follows:

$$CSF_{\text{dermal}} = (CSF_{\text{oral}}) / (ABS_{\text{GI}})$$

The oral CSF is divided by the absorption efficiency because CSFs are expressed as reciprocal doses. Dermal CSFs and the absorption efficiencies used in their determination are also included in Table 7-13.

7.3.2 Noncarcinogenic Effects

For noncarcinogens, it is assumed that there exists a dose below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. For noncarcinogens, a range of exposure exists that can be tolerated. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposures to a chemical above its threshold level. Maternal and developmental endpoints are considered systemic toxicity.

The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to an RfD. The RfD is expressed in units of mg/kg/day, and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern. An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs.

To derive an RfD, the USEPA reviews all relevant human and animal studies for each compound and selects the study (studies) pertinent to the derivation of the specific RfD. Each study is evaluated to determine the NOAEL or, if the data are inadequate for such a determination, the LOAEL. The NOAEL corresponds to the dose (in mg/kg/day) that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect." To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for (1) extrapolation of data from laboratory animals to humans (interspecies extrapolation), (2) variation in human sensitivity to the toxic effects of a compound (intraspecies differences), (3) derivation of a chronic RfD based on a subchronic

rather than a chronic study, and/or (4) derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 1 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is 1.

A dermal RfD is developed from an oral RfD by multiplying by the gastrointestinal tract absorption factor as follows:

$$RfD_{\text{dermal}} = (RfD_{\text{oral}})(ABS_{\text{GI}})$$

The resulting dermal RfD is, therefore, based on an absorbed dose, and can be used to estimate noncarcinogenic risks associated with the absorbed dose calculated by the dermal exposure algorithms.

RfDs for the COPCs at PSC 51 are presented in Table 7-14. The primary source of these values is the IRIS database (USEPA, 2000b), followed by other USEPA sources described for the carcinogens. Table 7-14 also includes the primary target organs affected by a particular chemical. This information may be used in the risk characterization section to segregate risks by target organ effects, unless the total Hazard Index (HI) is below unity. This ensures that "risks" are not overestimated when different compounds affect different target organs.

7.4 RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with the potential exposure to COPCs at PSC 51. Subsection 7.4.1 outlines the methods used to quantitatively estimate the type and magnitude of potential risks for human receptors. A summary of the risk characterization for PSC 51 is provided in Subsection 7.4.2.

7.4.1 Methodology for Estimation of Quantitative Risks

Potential human health risks resulting from exposure to COPCs are estimated using algorithms established by the USEPA (USEPA, 1989). The methods described by the USEPA are protective of human health and are likely to overestimate (rather than underestimate) risk. The methodology uses specific algorithms to calculate risk as a function of chemical concentration, human exposure parameters, and toxicity.

Table 7-14
Non-Cancer Toxicity Data - Oral/Dermal
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

[illegible]

Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. Some carcinogenic chemicals may also exhibit noncarcinogenic effects. Potential impacts are then characterized for both types of health effects.

7.4.1.1 Carcinogenic Effects

Risks attributable to exposure to carcinogenic COPCs are estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses, the incremental lifetime cancer risk (ILCR) is determined as follows (USEPA, 1989):

$$ILCR_i = (Intake_i)(CSF_i)$$

where: $ILCR_i$ = Incremental Lifetime Cancer Risk for chemical "i", expressed as a unitless probability
 $Intake_i$ = Intake of chemical "i" (mg/kg/day)
 CSF_i = Cancer slope factor of chemical "i" (kg/day/mg)

Estimated ILCRs are compared to the USEPA target risk range, 10^{-4} to 10^{-6} . Risks below 1×10^{-6} (1/1,000,000, or a risk less than 1 in 1 million) are generally considered to be "acceptable" by the USEPA, whereas risks greater than 1×10^{-4} (1 in 10,000) are generally considered to be "unacceptable" by the agency. Depending on the risk management goals for the site, risks within 10^{-4} to 10^{-6} are also typically regarded as "acceptable". FDEP has indicated that 1×10^{-6} is its cancer risk level of concern.

When carcinogenic risks exceed 1×10^{-2} using the above methodology, the USEPA (1989) specifies that the one-hit model be used, as follows:

$$ILCR_i = 1 - \exp(-Intake_i)(CSF_i)$$

Risks are estimated for all carcinogenic compounds regardless of the class designation (A, B, or C).

7.4.1.2 Noncarcinogenic Effects

The hazards associated with the effects of noncarcinogenic COPCs are evaluated by comparing an exposure level or intake to an RfD. The ratio of the intake to the RfD is called the HQ and is defined as follows (USEPA, 1989):

$$HQ_i = \frac{Intake}{RfD_i}$$

where: HQ_i = Hazard Quotient for chemical "i" (unitless)
 $Intake_i$ = Intake of chemical "i" (mg/kg/day)
 RfD_i = Reference Dose of chemical "i" (mg/kg/day)

A Hazard Index (HI) is generated by summing the individual HQs for all the COPCs. If the HI exceeds unity, there exists a potential for noncarcinogenic (toxic) effects to occur. When the HI exceeds unity, it is necessary to segregate the HQs by target organ effects since the HQs for all noncarcinogens are not considered to be truly additive unless similar target organs are affected.

The estimation of noncarcinogenic effects (i.e., the calculation of HQs/HIs) should not be construed as a probability in the manner of the ILCR, but rather a numerical indicator of the extent to which a predicted intake exceeds, or is less than, an RfD.

7.4.2 Results of the Risk Characterization

This section contains a summary of the results of the risk characterization for PSC 51. Potential cancer risks and HIs were calculated for construction workers site maintenance workers, occupational workers, adolescent and adult trespassers, and child and adult residents, are summarized in Table 7-15. Results of the risk assessment in RAGS Part D format are included in Appendix J. Sample calculations are also presented in Appendix J.

Future Construction Workers

All estimated cancer risks for construction workers were less than USEPA's target risk range of 10^{-4} to 10^{-6} and FDEP's level of concern of 1×10^{-6} . The estimated cancer risk for construction workers was 1.4×10^{-7} for exposure to surface soil and 2.6×10^{-8} for exposure to groundwater. The total cancer risk across all media was 1.6×10^{-7} .

All estimated HIs for the construction worker were less than the acceptable level of 1.0. The HIs for a construction worker were 0.08 for exposure to surface soil and 0.009 for exposure to groundwater indicating that no adverse health effects are anticipated for construction worker exposed to surface soil and groundwater under the defined conditions. The cumulative HI across all media was 0.09.

Current/future Maintenance Workers

The cancer risk estimate for a maintenance worker exposed to surface soil was 1.5×10^{-7} which is less than USEPA's target risk range of 10^{-4} to 10^{-6} and FDEP's level of concern of 1×10^{-6} . The HI for a

Table 7-15
Summary of Cancer Risks and Hazard Indices
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 10 ⁻⁴	Chemicals with Cancer Risks >10 ⁻⁵ and < 10 ⁻⁴	Chemicals with Cancer Risks >10 ⁻⁶ and < 10 ⁻⁵	Hazard Index	Chemicals with HI > 1
Construction Worker	Soil	Ingestion	1.3E-07	--	--	--	0.08	--
		Dermal Contact	3.6E-09	--	--	--	0.005	--
		Total	1.4E-07	--	--	--	0.08	--
	Groundwater	Ingestion	2.9E-09	--	--	--	0.0003	--
		Dermal Contact	2.3E-08	--	--	--	0.009	--
		Total	2.6E-08	--	--	--	0.009	--
	Total All Media						1.6E-07	
						0.09		
Maintenance Workers	Soil	Ingestion	1.2E-07	--	--	--	0.003	--
		Dermal Contact	3.0E-08	--	--	--	0.002	--
		Total	1.5E-07	--	--	--	0.004	--
Occupational Worker	Soil	Ingestion	9.7E-07	--	--	--	0.02	--
		Dermal Contact	9.5E-08	--	--	--	0.005	--
		Total	1.1E-06	--	--	Arsenic	0.03	--
Adolescent Trespassers	Soil	Ingestion	4.8E-07	--	--	--	0.03	--
		Dermal Contact	1.2E-08	--	--	--	0.002	--
		Total	4.9E-07	--	--	--	0.03	--
Adult Trespassers	Soil	Ingestion	2.8E-07	--	--	--	0.008	--
		Dermal Contact	3.6E-08	--	--	--	0.0023	--
		Total	3.2E-07	--	--	--	0.010	--

Table 7-15 (Continued)
Summary of Cancer Risks and Hazard Indices
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > 10 ⁻⁴	Chemicals with Cancer Risks >10 ⁻⁵ and < 10 ⁻⁴	Chemicals with Cancer Risks >10 ⁻⁶ and < 10 ⁻⁵	Hazard Index	Chemicals with HI > 1
Child Resident	Soil	Ingestion	6.1E-06	--	--	Arsenic	0.57	--
		Dermal Contact	2.2E-07	--	--	--	0.05	--
		Total	6.3E-06	--	--	Arsenic	0.61	--
	Groundwater	Ingestion	3.2E-05	--	Vinyl Chloride	1,1-DCE, Benzene	0.57	--
		Dermal Contact	1.4E-06	--	--	--	0.09	--
		Inhalation	NA	--	--	--	NA	--
		Total	3.3E-05	--	Vinyl Chloride	1,1-DCE, Benzene	0.66	--
	Total All Media		3.9E-05				1.3	
Adult Resident	Soil	Ingestion	2.6E-06	--	--	Arsenic	0.06	--
		Dermal Contact	3.4E-07	--	--	--	0.02	--
		Total	2.9E-06	--	--	Arsenic	0.08	--
	Groundwater	Ingestion	5.4E-05	--	Vinyl Chloride	1,1-DCE, Benzene	0.24	--
		Dermal Contact	3.5E-06	--	--	Benzene, Vinyl Chloride	0.06	--
		Inhalation	5.4E-05	--	Vinyl Chloride	1,1-DCE, Benzene	0.22	--
		Total	1.1E-04	--	Benzene, Vinyl Chloride	1,1-DCE	0.52	--
	Total All Media		1.2E-04				0.60	
Lifelong Resident	Soil	Ingestion	8.7E-06	--	--	Arsenic	NA	--
		Dermal Contact	5.5E-07	--	--	--	NA	--
		Total	9.2E-06	--	--	Arsenic	NA	--
	Groundwater	Ingestion	8.6E-05	--	Benzene, Vinyl Chloride	1,1-DCE	NA	--
		Dermal Contact	4.9E-06	--	--	Benzene, Vinyl Chloride	NA	--
		Inhalation	5.4E-05	--	Vinyl Chloride	Benzene, 1,1-DCE	NA	--
		Total	1.5E-04	Vinyl Chloride	Benzene	1,1-DCE	NA	--
	Total All Media		1.5E-04				NA	

Notes:
HI = Hazard Index
NA = Not Applicable

maintenance worker was 0.004 for exposure to surface soil indicating that no adverse health effects are anticipated for maintenance workers exposed to surface soil under the defined conditions.

Future Occupational Workers

The cancer risk estimate for an occupational worker exposed to surface soil was 1.1×10^{-6} , which is within USEPA's target risk range of 10^{-4} to 10^{-6} and essentially equal to FDEP's level of concern of 1×10^{-6} . The HI for an occupational worker was 0.03 for exposure to surface soil indicating that no adverse health effects are anticipated for an occupational worker exposed to surface soil under the defined conditions.

Current/future Adolescent Trespassers

The cancer risk estimate for an adolescent trespasser exposed to surface soil was 4.9×10^{-7} , which is less than USEPA's target risk range of 10^{-4} to 10^{-6} and FDEP's level of concern of 1×10^{-6} . The HI for an adolescent trespasser was 0.03 for exposure to surface soil indicating that no adverse health effects are anticipated for an adolescent trespasser exposed to surface soil under the defined conditions.

Current/future Adult Trespassers

The cancer risk estimate for an adult trespasser exposed to surface soil was 3.2×10^{-7} , which is less than USEPA's target risk range of 10^{-4} to 10^{-6} and FDEP's level of concern of 1×10^{-6} . The HI for an adult trespasser was 0.01 for exposure to surface soil indicating that no adverse health effects are anticipated for an adult trespasser exposed to surface soil under the defined conditions.

Hypothetical Future On-site Residents

All estimated cancer risks for the child resident were within USEPA's target risk range of 10^{-4} to 10^{-6} , but exceed FDEP's level of concern of 1×10^{-6} . The estimated cancer risks for the child resident were 6.3×10^{-6} for exposures to surface soil and 3.3×10^{-5} for exposure to groundwater. The total cancer risk across all media was 3.9×10^{-5} .

The estimated cancer risk for the adult resident exposed to surface soil was 2.9×10^{-6} , which is within USEPA's target risk range of 10^{-4} to 10^{-6} but exceeds FDEP's level of concern of 1×10^{-6} . The estimated cancer risk for the adult resident exposed to groundwater was 1.1×10^{-4} , which is at the upper bound of USEPA's target risk range and is above FDEP's level of concern. 1,1-DCE (ILCR = 6.2×10^{-6}), benzene

(ILCR = 2.1×10^{-5}), and vinyl chloride (ILCR = 8.4×10^{-5}) were the main contributors to the cancer risk for exposure to groundwater. The total cancer risk across all media was 1.2×10^{-4} .

The estimated cancer risk for the lifelong resident exposed to surface soil was 9.2×10^{-6} , which is within USEPA's target risk range of 10^{-4} to 10^{-6} , but exceeds FDEP's level of concern of 1×10^{-6} . The estimated cancer risk for the lifelong resident exposed to groundwater was 1.5×10^{-4} which is at the upper bound of USEPA's target risk range and is above FDEP's level of concern. 1,1-DCE (ILCR = 8.0×10^{-6}), benzene (ILCR = 2.7×10^{-5}) and vinyl chloride (ILCR = 1.1×10^{-4}) were the main contributors to the cancer risk for exposure to groundwater. The total cancer risk across all media was 1.5×10^{-4} .

All estimated HIs for the child resident were less than the acceptable level of 1.0. The HIs for a child resident was 0.61 for exposure to surface soil and 0.66 for exposure to groundwater indicating that no adverse health effects are anticipated for child resident exposed to surface soil and groundwater under the defined conditions. The cumulative HI across all media was 1.3.

All estimated HIs for the adult resident were less than the acceptable level of 1.0. The HIs for a adult resident was 0.08 for exposure to surface soil and 0.52 for exposure to groundwater indicating that no adverse health effects are anticipated for adult resident exposed to surface soil and groundwater under the defined conditions. The cumulative HI across all media was 0.60.

7.4.3 Risks Associated with Additional Soil Samples

As discussed in Section 5.0, an additional 14 surface soil samples were collected at the ODA in the fall and winter of 2002 and analyzed for arsenic to determine the extent of arsenic contamination. Also, 12 surface soil samples were collected in this area and analyzed for metals. Arsenic was detected at a maximum concentration of 4.3 mg/kg in the new samples from the ODA, and 6.1 mg/kg in the samples from the FFTA, as compared to a maximum concentration of 3.7 mg/kg in the original samples. However, the cancer risks resulting from exposures to arsenic in soil would be slightly lower if the new soil data was included in the risk assessment, since the maximum detected arsenic concentration of 3.7 mg/kg was used as the exposure point concentration in the risk assessment since there were an insufficient number of samples to calculate an UCL. Based on the new data, the UCLs of 1.68 mg/kg for the ODA and 2.98 mg/kg for the FFTA are less than the exposure point concentration of 3.7 mg/kg. Consequently, the cancer risks would be lower if the new data was used in the risk assessment, although the risks for residential exposures would still exceed 1×10^{-6} . As a result, the conclusions of HHRA pertaining to arsenic would not significantly change if the new soil data was included.

As shown in Table 5-2, in addition to arsenic, several noncarcinogenic metals were detected at concentrations that exceeded USEPA Region III RBCs (aluminum, antimony, chromium, and copper) and

FDEP SCTLs (aluminum, antimony, barium, chromium, copper, iron, lead, mercury, nickel, and vanadium) for residential exposures. Concentrations of lead exceeded the FDEP SCTL for industrial exposures at two locations, although, the 95 percent UCL of 685 mg/kg is less than the industrial SCTL of 920 mg/kg. It should be noted that the SCTLs for barium, copper, nickel, and vanadium are based on acute exposures to children exhibiting soil pica ingestion, which is not a typical exposure scenario. Since concentrations of these chemicals exceeded the residential RBCs and SCTLs, it is possible that hazard indices for residential exposures may exceed acceptable levels if the new soil sample data was evaluated in the human health risk assessment.

7.4.4 Risks Associated with Additional Groundwater Samples

As discussed in Section 5.0, an additional 80 groundwater samples were collected at PSC 51 in Fall 2001 and analyzed for benzene, toluene, ethylbenzene, xylenes, 1,2-DCE (cis & trans), TCE, vinyl chloride, and naphthalene to determine the horizontal and vertical extent of contamination. The additional groundwater data was not included in the HHRA since the majority of samples were collected with DPT and analyzed by a mobile laboratory, which provides screening quality data.

7.5 UNCERTAINTY ANALYSIS

There is uncertainty associated with all aspects of the baseline HHRA presented in this section. A summary of the uncertainties, including a discussion of how they may affect the final risk numbers, is provided in this section.

Uncertainty in the selection of COPCs is related to the current status of the predictive databases, the grouping of samples, and the procedures used to include or exclude constituents as COPCs. Uncertainty associated with the exposure assessment includes the values used as input variables for a given intake route/scenario, the assumptions made to determine exposure point concentrations, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment includes the quality of the existing toxicity data needed to support dose-response relationships and the weight-of-evidence used for determining the carcinogenicity of COPCs. Uncertainty in risk characterization includes that associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

While there are various sources of uncertainty, as described above, the direction of uncertainty can be influenced by the assumptions made throughout the risk assessment, including selection of COPCs and selection of values for dose-response relationships. Throughout the entire risk assessment, assumptions which consider safety factors are made so that the final calculated risks are overestimated.

Generally, risk assessments carry two types of uncertainty: measurement and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements. For example, this type of uncertainty is associated with analytical data collected for each site. The risk assessment reflects the accumulated variances of the individual values used.

Informational uncertainty stems from inadequate availability of information needed to complete the toxicity and exposure assessments. Often, this gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical, on the biological mechanism of action of a chemical, or the behavior of a chemical in soil.

Once the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to ensure that the particular assumptions made are protective of sensitive subpopulations or the maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward over predicting both carcinogenic and noncarcinogenic risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

This interpretation is especially relevant when the risks exceed the point-of-departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are below an "acceptable" risk level (i.e., 1×10^{-6}), the interpretation of no significant risk is typically straightforward. However, when risks calculated using a high degree of uncertainty are above an "acceptable" risk level (i.e., 1×10^{-4}), a conclusion can be difficult unless uncertainty is considered.

7.5.1 Uncertainty in Selection of COPCs

There is a minor amount of uncertainty associated with the selection of COPCs that may impact the numerical risk estimates presented in Section 7.4, Risk Characterization. The most significant issues related to uncertainty in COPC selection for PSC 51 are the screening levels used, and the absence of screening levels for a few chemicals detected in the site media. A brief discussion of each of these issues is provided in the remainder of this section.

COPC Screening Levels

The use of predetermined screening values based on conservative land use scenarios (i.e., residential land use for soil and sediment, and ingestion/inhalation for groundwater/surface water) in combination with the use of risk-based screening values corresponding to a 1×10^{-6} ILCR and a 0.1 HI, should ensure that the significant contributors to risk from a site are evaluated. The elimination of chemicals that are present at concentrations that correspond to a less than 1×10^{-6} ILCR and less than 0.1 HI should not affect the final conclusions of the risk assessment since these chemicals are not expected to cause a potential health concern.

There were no USEPA SSLs for migration of chemicals from soil to air for several chemicals; therefore, there is some uncertainty associated with the evaluation of the inhalation pathway. This uncertainty is expected to be insignificant because potential risks associated with exposures via incidental ingestion then usually there are unacceptable risks from exposure via incidental ingestion and dermal contact.

There were no USEPA SSLs for migration of chemicals from soil to groundwater for several chemicals. The uncertainty associated with the absence of these criteria is small. An exceedance of the SSLs does not mean that a chemical will definitely migrate from soil to groundwater, only that the potential for migration from soil to groundwater exists. Groundwater samples were collected at the site, and therefore real data is available to indicate whether chemicals have migrated from soil to groundwater at the site.

Absence of COPC Screening Levels

There was only one chemical (1-methylnaphthalene) for which there was no available USEPA Region III RBC but a FDEP SCTL was available. The RBC for 2-methylnaphthalene was used as a surrogate for 1-methylnaphthalene because the chemical structures of these chemicals are similar. Therefore, there is some uncertainty associated with screening 1-methylnaphthalene using the screening criteria for 2-methylnaphthalene. The maximum detected concentration of 1-methylnaphthalene is less than the FDEP SCTL for 1-methylnaphthalene and approximately six times lower than the RBC for 2-methylnaphthalene. Consequently, the absence of a RBC for 1-methylnaphthalene and the use of 2-methylnaphthalene as a surrogate does not effect the conclusions of the risk assessment.

7.5.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises because of the methods used to calculate exposure point concentrations, the determination of land use conditions, the selection of receptors and scenarios, and the selection of exposure parameters. Uncertainties associated with the exposure assessment are presented in this section.

Land Use

The current land use patterns at the site are well established, thereby reducing the uncertainty associated with land use assumptions. The site is currently not used for any purpose and there are no definite plans for the future use of the site.

Exposure Point Concentrations

There were an insufficient number of soil, surface water, and sediment samples collected to calculate UCLs; therefore the maximum detected concentration was used as the exposure point concentration. As a result, the estimations of risk, where the maximum concentrations were used as the exposure point concentration, are most likely overstated because it is unlikely that potential receptors would be exposed to the maximum concentration over the entire exposure period.

Exposure Routes and Receptor Identification

An attempt was made to simplify the various receptor groups and exposure routes of potential concern in this report. The uncertainty associated with this approach is minimal since exposure routes and potential receptors are considered to be well-defined, based on the limited land use observed at the site. In addition, exposure routes eliminated from further evaluation were excluded only after a qualitative evaluation of potential exposure.

Exposure Parameters

Each exposure factor selected for use in the risk assessment has some associated uncertainty. Generally, exposure factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid underestimation of exposure, the USEPA exposure assessment guidelines for the RME receptor were used to calculate COPC intake. These guidelines generally suggest the 95th percentile value for most parameters. Therefore, the selected values for the RME receptor represent the upper bound of the observed or expected habits of the majority of the population.

Generally, the uncertainty can be assessed quantitatively for a number of assumptions made in determining factors for calculating exposures and intakes. Many of these parameters were determined from statistical analyses on human population characteristics. Often the database used to summarize a particular exposure parameter (i.e., body weight) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty. For many parameters for which limited information exists (i.e., dermal absorption of organic chemicals from soil), there is greater uncertainty. However, there are often sufficient data to estimate these parameters with low uncertainty.

Many of the quantities used to calculate exposures and risks in this report are selected from a distribution of possible values. For the RME scenario, the value representing the 95th percentile is generally selected for each parameter to ensure that the assessment bounds the actual risks from a postulated exposure. This risk number is used in risk management decisions, but does not indicate what a more average or typical exposure might be, or what risk range might be expected for individuals in the exposed population.

USEPA's Dermal Exposure Assessment: Principles and Applications (USEPA, 1992b) was used to evaluate dermal exposures to soil and groundwater. This guidance recommends a value of 1.0 mg/cm^2 be used for the soil adherence factor which is also the same value recommended by USEPA Region IV. USEPA is currently revising the dermal guidance and the new soil adherence factors are lower than the existing values. Soil adherence factors recommended by the new guidance range from 0.07 mg/cm^2 for an adult resident to 0.2 mg/cm^2 for child residents and industrial workers. Therefore, dermal exposures based on the USEPA Region IV guidance and the 1992 dermal guidance may overestimated the risks from exposures to soil.

7.5.3 Uncertainty in the Toxicological Evaluation

Uncertainties associated with the toxicity assessment (determination of RfDs and CSFs and use of available criteria) are presented in this section.

Derivation of Toxicity Criteria

Uncertainty associated with the toxicity assessment is associated with hazard assessment and dose-response evaluations for the COPCs. The hazard assessment deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using the USEPA methods. Positive animal cancer test data suggest that humans contain tissue(s) that may also manifest a carcinogenic response. However, the

animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncancer effects, however, positive animal data suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans.

Uncertainty in hazard assessment arises from the nature and quality of the animal and human data.

Uncertainty is reduced

- When similar effects are observed across species, strain, sex, and exposure route.
- When the magnitude of the response is clearly dose-related.
- When pharmacokinetic data indicate a similar fate in humans and animals.
- When postulated mechanisms of toxicity are similar for humans and animals.
- When the chemical of concern is structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation includes the determination of a CSF for the carcinogenic assessment and derivation of an RfD for the noncarcinogenic assessment. Uncertainty is introduced from interspecies (animal to human) extrapolation, which, in the absence of quantitative pharmacokinetic or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also results from intraspecies variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity including unusual sensitivity or tolerance to the COPC. Even toxicity data from human occupational exposure reflect a bias, because only those individuals sufficiently healthy to attend work regularly (the "healthy worker effect") and those not unusually sensitive to the chemical, are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study from which the quantitative estimate is derived and the database. For cancer effects, the uncertainty associated with dose-response factors is mitigated by assuming the 95 percent upper bound for the slope factor. Another source of uncertainty in carcinogenic assessment is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. There is evidence to suggest, however, that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Williams and Weisburger, 1991); therefore, the use of the linearized multistage model is conservative for chemicals that exhibit a threshold for carcinogenicity.

For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD to mitigate poor quality of the key study or gaps in the data base. Additional uncertainty for noncancer effects arises from the use of an effect level in the estimation of an RfD, because this estimation is

predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises in estimation of an RfD for chronic exposure from less-than-chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less-than-chronic study. Uncertainty in the derivation of RfDs is mitigated by the use of uncertainty and modifying factors that normally range between 3 and 10. The resulting combination of uncertainty and modifying factors may reach 1,000 or more.

The derivation of dermal RfDs and CSFs from oral values may cause uncertainty. This is particularly the case when no gastrointestinal absorption rates are available in the literature or when only qualitative statements regarding absorption are available. Whenever possible gastrointestinal absorption rates from USEPA Region IV were used for all chemicals in the HHRA.

Use of Arsenic Toxicity Criteria

Although the more restrictive basis for evaluating risk associated with exposure to arsenic is to assume it is a carcinogen, carcinogenic effects are not the primary health effects expected to be manifested upon exposure to arsenic. The preponderance of scientific information indicates that humans are capable of metabolizing arsenic to expedite its elimination from the body (ATSDR, 1988). Its elimination from the body obviously mitigates the possibility for arsenic to manifest carcinogenic effects. Therefore, evaluating arsenic as a noncarcinogen would be more appropriate.

Specifically, the body methylates the arsenic to form monomethyl arsenic and dimethyl arsenic. There is a limited capacity for the body to methylate arsenic, but this limit is generally reached when the body's intake of arsenic approximately exceeds 500 µg/day. For example, the maximum detected concentration of arsenic in surface at the site was 3.7 mg/kg. Assuming a soil ingestion rate of 200 mg per day, exposure to this concentration corresponds to approximate intake of 0.74 µg/day. This concentration results in an intake that is well within the body's ability to metabolize arsenic. Although some humans may be more sensitive to arsenic, in that they are "poor methylators," the average exposure concentration for the site is more than two orders of magnitude below the normal limit of metabolic saturation and is most likely below levels, which would trigger responses in sensitive individuals.

Use of Toxicity Criteria from The National Center for Environmental Assessment (NCEA)

National Center for Environmental Assessment (NCEA) provisional RfDs are used to evaluate noncarcinogenic effects from exposure to 1,2-dichloroethane, benzene, 2-methylnaphthalene, TCE, and iron; and a provisional CSF is used to evaluate carcinogenic effects from TCE. The provisional RfDs for iron is based on the Food and Drug Administration (FDA) Recommended Daily Allowance (RDA). Therefore, there is some degree of uncertainty associated with the use of these toxicity criteria, although the uncertainty is expected to be insignificant since none of these chemicals were identified as major contributors to the estimated cancer risk and HIs.

7.5.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization results primarily from assumptions made regarding additivity of effects from exposure to multiple COPCs from various exposure routes. High uncertainty exists when summing cancer risks for several substances across different exposure pathways. This assumes that each substance has a similar effect and/or mode of action. Often compounds affect different organs, have different mechanisms of action, and differ in their fate in the body, so additivity may not be an appropriate assumption. However, the assumption of additivity is made to provide a conservative estimate of risk.

Finally, the risk characterization does not consider antagonistic or synergistic effects. Little or no information is available to determine the potential for antagonism or synergism for the COPCs. Therefore, this uncertainty cannot be discussed for its impact on the risk assessment, since it may either underestimate or overestimate potential human health risk.

7.6 REMEDIAL GOAL OPTIONS

In accordance with USEPA Region IV guidance, Remedial Goal Options (RGOs) were developed for those media with estimated lifetime cancer risks greater than 1×10^{-4} and total HI greater than 1.0. In addition, RGOs were also developed for media with cancer risks above the FDEP target risk level of 1×10^{-6} . As discussed in Section 7.4 cancer risk estimates for child and adult residents hypothetically exposed to soil exceed the FDEP target cancer risk level of 1×10^{-6} , consequently RGOs were developed for these receptors. Cancer risk estimates for lifelong residents exposed to vinyl chloride in groundwater exceed USEPA's and FDEP target risk range. In addition, cancer risk estimates developed for hypothetical resident exposure to 1,1-DCE and benzene in groundwater exceed FDEP's target risk level. Therefore, RGOs will be developed for exposures to benzene, 1,1-DCE, and vinyl chloride in groundwater.

RGOs for PSC 51 were developed according to guidance provided in the USEPA Region IV HHRA Bulletins. The RGOs were calculated using the following equation:

$$\text{RGO}[\text{chemical } i] = \text{EPC}[\text{chemical } i] \times \text{Target Risk} / \text{Calculated Risk}[\text{chemical } i]$$

Where:

RGO[chemical i] = the chemical-specific remediation goal option.

EPC[chemical i] = the exposure point concentration for the chemical used in risk assessment calculations.

Target Risk = Target risk for carcinogens or the Target Hazard Quotients for noncarcinogens.

Calculated Risk[chemical i] = the total risk calculated for a specific chemical in the risk assessment.

In accordance to the USEPA Region IV guidance, RGOs are based on target cancer risks of 1×10^{-6} , 1×10^{-5} , and 1×10^{-4} and the target Hazard Quotients of 0.1, 1, and 3.

The chemical-specific RGOs for child, adult, and lifelong residents are presented in Tables 7-16 and 7-17.

7.7 SUMMARY OF HUMAN HEALTH RISK ASSESSMENT

The following bullets summarize the HHRA at PSC 51.

- The HHRA considered exposures to future construction workers, current/future maintenance workers, future occupational workers, current/future adolescent trespassers, current/future adult trespassers, hypothetical future child residents, and hypothetical future adult residents.
- No COPCs were identified for surface water and sediment, consequently no adverse health effects are anticipated for exposure to these media.
- Incremental lifetime cancer risks for all receptors exposed to soil were less than or within USEPA's target cancer risk range of 10^{-4} to 10^{-6} . Although incremental lifetime cancer risks for the occupational worker, child resident, and adult resident exceeded FDEP's target risk level of 1×10^{-6} , arsenic was the only chemical in soil with cancer risks greater than 1×10^{-6} .

Table 7-16
Remedial Goal Options for Soil
PSC 51

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CHILD RESIDENT							
Chemical	Target Cancer Risk Level			Target Hazard Index			ARARS
	10 ⁻⁶ (mg/kg)	10 ⁻⁵ (mg/kg)	10 ⁻⁴ (mg/kg)	0.1 (mg/kg)	1 (mg/kg)	3 (mg/kg)	FDEP (mg/kg)
Arsenic	0.588	5.88	58.8	2.27	22.7	68.0	0.8

ADULT RESIDENT							
Chemical	Target Cancer Risk Level			Target Hazard Index			ARARS
	10 ⁻⁶ (mg/kg)	10 ⁻⁵ (mg/kg)	10 ⁻⁴ (mg/kg)	0.1 (mg/kg)	1 (mg/kg)	3 (mg/kg)	FDEP (mg/kg)
Arsenic	1.26	12.6	126	19.4	194	582	0.8

LIFELONG RESIDENT							
Chemical	Target Cancer Risk Level			Target Hazard Index			ARARS
	10 ⁻⁶ (mg/kg)	10 ⁻⁵ (mg/kg)	10 ⁻⁴ (mg/kg)	0.1 (mg/kg)	1 (mg/kg)	3 (mg/kg)	FDEP (mg/kg)
Arsenic	0.400	4.00	40.0				0.8

Table 7-17
Remedial Goal Options for Groundwater
PSC 51

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

CHILD RESIDENT								
Chemical	Target Cancer Risk Level			Target Hazard Index			ARARs	
	10⁻⁶ (mg/L)	10⁻⁵ (mg/L)	10⁻⁴ (mg/L)	0.1 (mg/L)	1 (mg/L)	3 (mg/L)	FED-MCL (mg/L)	FDEP (mg/L)
1,1-DCE	0.283	2.83	28.3	13.1	131	392	7	7
Benzene	3.04	30.4	304	4.31	43.1	129	5	1
Vinyl Chloride	0.094	0.935	9.35	NA	NA	NA	2	1

ADULT RESIDENT								
Chemical	Target Cancer Risk Level			Target Hazard Index			ARARs	
	10⁻⁶ (mg/L)	10⁻⁵ (mg/L)	10⁻⁴ (mg/L)	0.1 (mg/L)	1 (mg/L)	3 (mg/L)	FED-MCL (mg/L)	FDEP (mg/L)
1,1-DCE	0.084	0.839	8.39	15.5	155	466	7	7
Benzene	0.906	9.06	90.6	5.13	51.3	154	5	1
Vinyl Chloride	0.027	0.274	2.74	NA	NA	NA	2	1

LIFELONG RESIDENT								
Chemical	Target Cancer Risk Level			Target Hazard Index			ARARs	
	10⁻⁶ (mg/L)	10⁻⁵ (mg/L)	10⁻⁴ (mg/L)	0.1 (mg/L)	1 (mg/L)	3 (mg/L)	FED-MCL (mg/L)	FDEP (mg/L)
1,1-DCE	0.065	0.647	6.47	NA	NA	NA	7	7
Benzene	0.698	6.98	69.8	NA	NA	NA	5	1
Vinyl Chloride	0.021	0.212	2.12	NA	NA	NA	2	1

- HIs for all receptors exposed to soil were less than the USEPA and FDEP acceptable level of 1.0 indicating that there is minimal potential for adverse health effects under the conditions established in the risk assessment.
- The incremental lifetime cancer risk for the future construction worker exposed to groundwater was less than USEPA's and FDEP's target cancer risk levels.
- The incremental lifetime cancer risks for the hypothetical future child resident exposed to groundwater was within USEPA's target cancer risk of 10^{-4} to 10^{-6} but exceeded FDEP's target cancer risk level of 1×10^{-6} . The incremental lifetime cancer risks for the hypothetical future adult resident exposed to groundwater exceeded USEPA's target cancer risk range and FDEP's target cancer risk level. Benzene, 1,1-DCE, and vinyl chloride were the main contributors to the cancer risk in groundwater.
- HIs for all receptors exposed to groundwater were less than the USEPA and FDEP acceptable level of 1.0 indicating that there is minimal potential for adverse health effects under the conditions established in the risk assessment.

8.0 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT (ERA)

This screening-level ERA (SLERA) is prepared in accordance with USEPA guidance, as outlined in Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997b). The goal of the assessment is to ascertain the need for additional study of PSC 51 at the NAS Jacksonville in Jacksonville, Florida. If more work is needed, the assessment is also intended to inform decisions about the type of study to be performed.

The ecological risk assessment is an eight step process, the first two of which are the screening level assessment. As shown in Figure 8-1, at several points during the risk assessment process a scientific/management decision point (SMDP) is reached. An SMDP requires a meeting between the risk managers and the risk assessment team to evaluate and approve or redirect the work up to that point (USEPA, 1997b). After the SLERA is completed, the need for further evaluation in the form of a baseline ERA is decided at the first SMDP. In this assessment, the first two steps of the ERA are completed. In addition, a portion of step 3 is included to refine the potential risk to ecological receptors.

Section 8.1.1 provides the environmental and site settings for PSC 51 at the NAS Jacksonville in Jacksonville, Florida. The fate and transport characteristics of the constituents detected in sampled media are provided in Section 8.1.2. The ecotoxicity of site contaminants and potential ecological receptors are outlined in Section 8.1.3. Section 8.2 describes complete exposure pathways, while Section 8.3 provides assessment and measurement endpoints. Sections 8.4 and 8.5, respectively, include the toxicity evaluation and exposure estimates for PSC 51. The ecological effects characterization is provided in Section 8.6, while the risk calculation is provided in Section 8.7. The uncertainties associated with the ERA are discussed in Section 8.8. Finally, the summary and conclusion of this SLERA, along with recommendations, are provided in Section 8.9.

8.1 PROBLEM FORMULATION

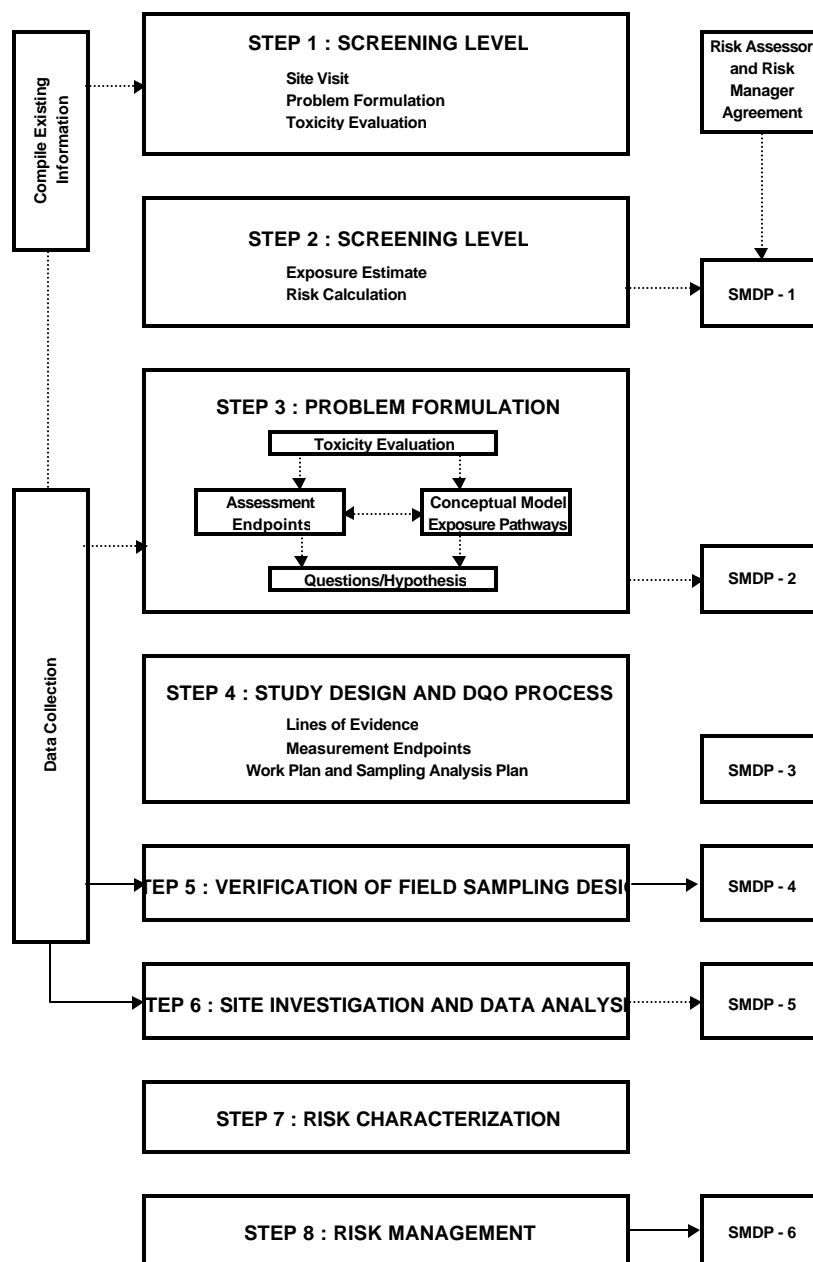
8.1.1 Environmental Setting

The topography in northeast Florida is generally flat, characterized by a series of ancient marine terraces indicated by low seaward sloping scarps that parallel the present shoreline. Seven terraces are present in northeast Florida, with NAS Jacksonville located within the Pamlico terrace (10-25 ft msl). The

FIGURE 8-1

Rev. 2
09/06/02

EIGHT STEP ECOLOGICAL RISK ASSESSMENT PROCESS FOR SUPERFUND



Scientific/Management Decision Points (SMDPs)

- 1 - Decision whether a full ecological risk assessment is necessary
- 2 - Agreement from all involved parties on the conceptual model, including assessment endpoints, exposure pathways, and questions or risk hypotheses.
- 3 - Agreement on the measurement endpoints, study design, and data interpretation and analysis.
- 4 - Signing approval of the work plan and sampling and analysis plan for the ecological risk assessment.
- 5 - Agreement point - only if change to sampling and analysis plan is necessary.
- 6 - Signing of the Record of Decision.

topography of PSC 51 is also generally flat, with a slight inclination to the south. As explained previously, PSC 51 includes the ODA and the FFTA. Considering the patterns formed by the surface soil sampling locations (Figure 4-1), they can be thought of as two circular areas, each about 1 acre in area. The ODA is closest to the patrol road, with its center about 200 ft northwest of the road. The FFTA is about 300 ft northwest of the ODA. A pine forest abuts PSC 51 to the north and west. The tree line is about 700 ft north and 300 ft west of the FFTA. PSC 51 is mostly covered by mowed grass and forbs (40 to 100 percent cover), with small scattered patches of bare sandy soil (0 to 60 percent bare ground). Soil and geological information, as well as more detail on the environmental setting, including climate and hydrogeology, are presented in Section 2.0.

NAS Jacksonville lies entirely within the St. Johns River basin. Surface water features in proximity to the site include the St. Johns River, located approximately 2,000 ft east of PSC 51, and an unnamed creek located south and east of PSC 51 that drains to the St. Johns River. The creek begins between Patrol Road and Allegheny Road and runs east toward the river. A ditch that lies between Patrol Road and PSC 51 is continuous with the creek bed. At approximately 300 ft west of the intersection of Patrol Road and Allegheny Road, the ditch turns under Patrol Road, away from the site, and off the base. Standing water (the beginning of the stream) occurs about 100 ft east of the point where the ditch goes under Patrol Road and leaves base property. Potentially, runoff from most of the site could enter the ditch and eventually reach the stream. Runoff from the eastern part of the site would be directed to another ditch that goes under Patrol Road near its intersection with Allegheny Road, runs along the western side of Allegheny Road, and merges with the stream where it goes under Allegheny Road. Because the site is flat, runoff, if it occurs, is expected to be sheet flow with low velocity and minimal erosion.

The creek averages approximately 10 ft in width and is a very low gradient stream. Where the creek is near the site, water flow apparently only occurs during storm events. The substrate of the stream is sand with a thick layer of muck. Locations in the stream near its off-base origin have some domestic trash, such as old bicycles.

The creek has been incorporated into the sampling program at PSC 51 because the groundwater from the surficial aquifer discharges into the creek and may serve as a source of surface water contamination (HLA, 1999a). The creek is believed to serve as a discharge pathway for stormwater drainage from the southern portion of the base into the St. Johns River (TtNUS, 1999a), which includes surface water runoff from the PSC 51. However, since the ground surface of PSC 51 is mostly unpaved and consists of sandy soils, it is likely the majority of rainwater soaks into the ground, leaving little opportunity for sheet flow to occur. After leaving the area near PSC 51, the creek meanders through an older, predominately residential area. According to the USGS, groundwater flow from the neighborhood and the southern

portion of the station both discharge into the creek. In proximity to the creek, there is a strong gradient toward the creek from both sides.

Contaminants currently associated with the ODA and the FFTA include VOCs, SVOCs and heavy metals. TtNUS conducted groundwater, surface water, soil and sediment sampling at the site between December 15 and 22, 1999. In addition, surface soil sampling was conducted in October 2001 and January 2002 to further characterize surface soil metals at PSC 51. All of the TtNUS samples were included in this SLERA. The sampling activities are described in more detail in Section 4.0.

BEI completed site investigation and interim measures at the site during March to October 1998. BEI's field activities included the identification and removal of soil contaminated with lead and radionuclides, the installation of two groundwater monitoring wells, radiological and lead confirmatory sampling, chemical sampling for use in the RI, and the backfilling of the excavations with clean soil. Using a Ludlum 2221 to screen soils, the areal extent of radiologically contaminated soil was determined to correspond to the areas of stressed vegetation exhibited at each site. Soils were removed from the ODA and the FFTA. Reportedly, the ODA contained a layer of black oily material mixed with soil in a large concave depression. The excavation revealed a 20-gallon drum containing black sludge, which was removed. Twenty-seven confirmation samples were collected from the excavations of the ODA and the FFTA. Only one sample exceeded the USEPA radiological criteria. A confirmatory radiological survey of the sample location was performed to assure that the contaminated soil had been excavated to its horizontal and vertical extent. The survey indicated that the soil at the extents of the excavation did not exceed USEPA radiological criteria. Fourteen surface soil samples collected by BEI after the excavation were also included in this assessment.

8.1.2 Contaminant Fate and Transport

VOCs, SVOCs and heavy metals are the contaminants associated with the ODA and the FFTA. VOCs generally volatilize to the atmosphere from surface soil and surface water. VOCs in soil will dissolve in water to varying degrees and may be transported overland with runoff or via groundwater to surface waters. Photolysis and hydrolysis are not significant mechanisms for VOC degradation; however, aerobic biodegradation in soil, groundwater and surface water is significant, and anaerobic degradation can also occur in these media. VOCs are not known to bioaccumulate in ecological receptors.

SVOCs adsorb to soils at varying degrees depending on the soil's organic carbon content and properties of the compound. SVOCs will leach to groundwater and there is some volatilization to the atmosphere from both soils and surface water. Surface water contamination from SVOCs will generally occur as a result of contaminated groundwater discharge and/or erosion of contaminated soil into surface water. Biodegradation of SVOCs is significant in groundwater, surface water and soil. Some SVOCs, like

naphthalene, will experience significant photolysis in surface water. Hydroxyl and nitrate radicals generally degrade SVOCs released to air. SVOCs will moderately bioaccumulate in fish and aquatic invertebrates. However, SVOCs are not known to biomagnify in terrestrial or aquatic ecosystems.

Heavy metals are generally persistent in soil, not significantly volatilizing. Metals will leach from soil to groundwater at varying degrees, depending on the pH of the infiltrating water and other factors. Metals will dissolve in water and may enter surface water via direct contact, groundwater discharge or erosion of contaminated soil. Metals can be released to air via adsorption to dust particles and wind erosion of contaminated soil. Metals do not degrade, but they can be complexed by organic matter or bound to inorganic components of particles so that they are not bioavailable. Some metals, such as arsenic, cadmium, lead, and mercury, may bioconcentrate within some ecological receptors. However, only methyl mercury is known to biomagnify significantly and this process is typical only in of aquatic ecosystems. Sixteen metals were retained as COPCs because they had maximum surface soil levels greater than ecological screening values; additional information is in the appended chemical profiles.

8.1.3 Ecotoxicity and Potential Receptors

The groups of chemicals for which there is concern are VOCs in surface soil, surface water, and sediment, naphthalene (an SVOC) in surface soil; and metals in surface soil. These groups were also detected in groundwater. Because there is no direct exposure of commonly evaluated ecological receptors to groundwater, there is no basis for examining the ecological toxicity of constituents in that medium. Toxicological information is included here on chemicals that are COPCs, meaning they had maximum values greater than screening levels. COPCs are described that have information on their toxicity; for groups that have many COPCs (metals) they serve as examples for COPCs in the same chemical category. More information regarding the toxicity of site COPCs is in the appended chemical profiles.

The VOCs that had maxima exceeding screening levels in exposure media were ethylbenzene, naphthalene, 1,2,3-trichlorobenzene, and xylenes. Aquatic toxicity for VOCs in general is low to moderate. The acute toxicity of xylene to birds is low (HSDB, 2002). In mammals, VOCs tend to affect the central nervous system, while chlorinated VOCs, such as 1,2,3-trichlorobenzene, are toxic to the liver.

Naphthalene is a PAH and it is the only SVOC of concern in media to which ecological receptors may be exposed. PAHs may be toxic to fish, aquatic invertebrates, birds, and mammals. Toxicity from PAHs is variable among aquatic organisms, and may be increased by the effects of light. Within fish, chronic exposure to PAHs has been linked to tumors believed to be associated with biotransformation of PAHs by mixed-function oxidase enzymes into carcinogenic and mutagenic intermediates (Eisler, 1987). In

mammals, PAHs typically do not demonstrate acute toxicity. The most significant aspect of PAHs toxicity in mammals is their well-documented carcinogenicity.

All of the metal COPCs except barium are known to affect a broad range of organisms, from microorganisms to higher plants and animals. Barium has not been evaluated for toxicity to the extent that the other metals have, but it is not generally regarded as having significant ecological toxicity.

It is difficult to make generalizations about the toxic actions of metals because of diverse affinities for organic molecules in biologic structures, a wide array of biological effects, and a multiplicity of target organs and systems (Amdur et al., 1991). At the molecular level metals may exert toxicity through multiple properties including selective accumulation in target organs (such as the kidneys), substitution for "essential" metals, and mimicking essential substrates (Clarkson, 1983). These reactions of metals at the molecular level typically affect enzyme systems leading to a variety of effects including disruption of cellular transport, cellular respiration, cell division, and other important processes.

Metal toxicity to aquatic organisms is manifested through a broad spectrum of effects that may range from reductions in growth rate to death. Mollusks and fish are generally more tolerant of exposures to elevated metal concentrations than other aquatic organisms. Embryonic and larval stages of aquatic organisms are typically the life cycle stages most sensitive to metal toxicity.

Potential receptors include soil-dwelling organisms, terrestrial plants, sediment-dwelling organisms, water column organisms, aquatic plants, and organisms that eat the aforementioned. Therefore, there is a potential for receptors such as songbirds or rodents to be adversely affected by the metal COPCs in surface soil. In turn, the animals that prey on rodents may become exposed. Based on environmental fate data, higher level predators are not a concern for VOCs in the aquatic food chain.

8.2 COMPLETE EXPOSURE PATHWAYS

Potentially complete exposure pathways and routes of entry into the biota include the following:

- Direct contact with soil.
- Inhalation of soil entrained in air.
- Leaching from soil and transport in groundwater to surface water and sediment.
- Erosion of contaminants in soil and overland transport to surface water and sediment.
- Direct contact with water and sediment.
- Incidental ingestion of soil or sediment.

- Ingestion of surface water.
- Ingestion of contaminated organisms.

Although potentially complete, some pathways may not actually be complete. One way to assess this is to compare chemical concentrations in the media sampled. For example, if a chemical is detected in surface soil but not in groundwater, then the groundwater pathway to surface water may not be complete. Another source of evidence is the fate and transport information previously presented. After the site chemical data are evaluated, pathways that are not likely to be complete will be described in discussions of the disposition of individual COPCs.

8.3 ASSESSMENT AND MEASUREMENT ENDPOINTS

Regarding contamination at a site, the goal of environmental protection is to ensure that the structure and function of the living system is similar to what it would be without contamination. This is very difficult to test or measure directly, so it is assumed that if populations of native organisms are reproducing successfully, the goal will be met. Therefore, the “assessment endpoint” of this assessment is the successful reproduction of

- Soil-dwelling organisms (invertebrates).
- Terrestrial plants.
- Populations of mammals feeding on invertebrates.
- Populations of birds feeding on invertebrates.
- Populations of mammals feeding on terrestrial plants.
- Sediment-dwelling organisms.
- Pelagic/planktonic organisms.
- Aquatic plants.

Chronic toxicological data on the tendency of COPCs to cause mortality or serious developmental or reproductive effects can be used to address the protection goal. For plants, invertebrates, and fish, toxicological data are typically expressed as a concentration associated with an effect (or the lack of an effect). Therefore, the “measurement endpoints” are the concentrations in soil, water, and sediment that are associated with either no effects or a low threshold of effects to the biota. For birds and mammals, toxicological data are typically expressed as an ingested dose. So, the measurement endpoints for these receptors are doses associated with no effect, or a low threshold of effects.

Risks to birds and mammals were evaluated using food chain models. Food chain modeling requires the identification of particular species. The American robin (insectivorous bird), the short-tailed shrew

(insectivorous mammal), and the meadow vole (herbivorous mammal) were selected. These species were chosen to represent their ecological guilds using the following criteria: their small body size, ecological importance, and the availability of life history data. Smaller body size typically results in relatively higher contaminant dose, making the modeling more conservative. PSC 51 provides no habitat for larger terrestrial receptors or aquatic receptors. In fact, even small animals may make little use of the site. Therefore, only small terrestrial species are considered in the food chain modeling.

8.4 TOXICITY EVALUATION

Toxicity, or ecological effects, data are of two general types: (1) direct toxicity to contaminants in site media, and (2) toxic responses to contaminated food. This section describes the guidelines used in this risk assessment to characterize effects to ecological receptors.

8.4.1 Toxicity Screen

Direct toxicity occurs for invertebrates and plants that are exposed to contaminants in soil and for the aquatic life in the water column exposed to chemicals in water. Direct effects are usually quantified as threshold chemical concentrations in a medium. Effects may also be assessed from toxicity testing or community/population study in the field. In this assessment, direct toxicity is assessed using threshold guideline values, the USEPA Region IV screening values, compared to the concentrations of analytes detected in site media.

Guideline concentrations for chronic exposure are levels below which effects are rare and above which effects are more likely. The chronic guideline value is set low enough to preclude effects if a contaminant concentration does not exceed it. If the guidelines are exceeded, there is more likelihood that mortality and other effects may occur. If site concentrations fall below the threshold values, then adverse effects are unlikely to occur.

USEPA Region IV surface soil screening levels were used to evaluate potential direct toxicity risk to terrestrial plants, invertebrates, and terrestrial receptors (Table 8-1). Both maximum and average concentrations detected in surface soil are included and compared to guidelines in Table 8-1 to provide risk managers with a range of values for basing decisions. In addition, the concentration of surface soil COPCs will be discussed in comparison to acute surface soil guidelines based on the Dutch HC50 values (Dutch; MVRM, 2000). These values are based on a standard soil containing 10 percent organic matter and 25 percent clay, but the clay fractions at the site are unknown.

Table 8-1
Selection of Chemicals of Preliminary Concern - Surface Soil
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Chemical	Frequency of Detection	Range of Detection (mg/kg)		Mean*	Location of Maximum	USEPA Region IV Screening Level (mg/kg)	Maximum Hazard Quotient	Mean Hazard Quotient	Selected as COPC (Y/N?)	NAS Jacksonville Background (mg/kg)	Notes
		Min.	Max.								
Volatile Organic Compounds											
1,2,3-Trichlorobenzene	2 / 9	0.2	0.22	0.11	JX00938	0.01	22	11	Y		Value for chlorobenzene
1,2,4-Trimethylbenzene	9 / 13	0.001	8.1	1.94	JX00939	NA	NA	NA	Y		no screening data
1,3,5-Trimethylbenzene	8 / 14	0.84	6	1.42	JX00942	NA	NA	NA	Y		no screening data
Butylbenzene, n-	6 / 8	0.24	0.9	0.41	JX00939	NA	NA	NA	Y		no screening data
Butylbenzene, s-	6 / 8	0.18	0.54	0.29	JX00939	NA	NA	NA	Y		no screening data
Ethylbenzene	7 / 14	0.00022	2.7	0.45	JX00942	0.05	54	9	Y		
Hexachlorobutadiene	2 / 8	0.21	0.23	0.12	JX00934	NA	NA	NA	Y		no screening data
Isopropylbenzene	5 / 9	0.2	0.83	0.26	JX00942	NA	NA	NA	Y		no screening data
Isopropyltoluene, p-	7 / 8	0.23	0.95	0.51	JX00939	NA	NA	NA	Y		no screening data
Naphthalene	7 / 8	0.73	4.9	2.01	JX00939	0.1	49	20	Y		
Propylbenzene, n-	8 / 9	0.18	2.1	0.63	JX00942	NA	NA	NA	Y		
Toluene	2 / 14	0.0016	0.002	0.002	JX00950	0.05	0.04	0.03	N		
Xylene, o-	8 / 14	0.4	4.9	0.922	JX00942	0.05	98	18	Y		value for xylene
Xylene, m- and p-	8 / 14	0.51	9.9	1.82	JX00942	0.05	198	36	Y		value for xylene
Semivolatile Organic Compounds											
1-Methylnaphthalene	7 / 8	0.46	1.3	0.796	JX00939	NA	NA	NA	Y		no screening data
2-Methylnaphthalene	7 / 8	0.7	2.1	1.22	JX00935	NA	NA	NA	Y		no screening data
Naphthalene	5 / 13	0.0057	0.65	0.2	JX00935	0.1	6.5	2.0	Y		
Metals											
Aluminum	12 / 12	1460	79200	25758	SS26A	50	1,584	515	Y	31.8 - 1710	
Antimony	7 / 8	0.37	46.7	16	SS22	3.5	13	4.5	Y		
Arsenic	30 / 38	0.24	17	2	JX00934	10	2	0.19	Y	0.29 - 0.6	
Barium	16 / 16	9.6	319	79	SS26A	165	2	0.48	Y	1.1 - 12.7	
Beryllium	4 / 5	0.22	0.8	0.4	SS26A	1.1	0.73	0.35	N		
Cadmium	8 / 13	0.21	24	5	SS26A	1.6	15	3.3	Y		
Calcium	11 / 12	157	8550	1996	SS26A	NA	NA	NA	N	48.2 - 6200	Nutrient
Chromium	23 / 24	5.4	1280	203	SS22	0.4	3,200	507	Y	1.5 - 4.6	
Cobalt	4 / 5	2.6	9.6	5	SS22	20	0.48	0.27	N		
Copper	12 / 12	11	7310	2479	SS21	40	183	62	Y		
Iron	12 / 12	228	40400	14148	SS22	200	202	71	Y	124 - 928	
Lead	23 / 23	3.3	1190	233	SS26A	50	24	4.7	Y	1.2 - 26.6	
Magnesium	14 / 16	20	1290	570	SS26A	NA	NA	NA	N	15.9 - 154	Nutrient
Manganese	5 / 5	10	891	471	SS22	100	8.9	4.7	Y	1.4 - 37.4	
Mercury	7 / 7	0.01	5.4	1.3	SS22	0.1	54	13	Y		

Table 8-1
Selection of Chemicals of Preliminary Concern - Surface Soil
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

<i>Chemical</i>	<i>Frequency of Detection</i>	<i>Range of Detection (mg/kg)</i>		<i>Mean*</i>	<i>Location of Maximum</i>	<i>USEPA Region IV Screening Level (mg/kg)</i>	<i>Maximum Hazard Quotient</i>	<i>Mean Hazard Quotient</i>	<i>Selected as COPC (Y/N?)</i>	<i>NAS Jacksonville Background (mg/kg)</i>	<i>Notes</i>
		<i>Min.</i>	<i>Max.</i>								
Nickel	12 / 12	3.1	544	160	SS22	30	18	5.3	Y	2.8 - 14.7	
Potassium	4 / 5	95	284	158	SS26A	NA	NA	NA	N		Nutrient
Selenium	4 / 13	2.4	4.4	2.1	JX00934	0.81	5.4	2.6	Y		
Silver	4 / 5	3.0	10.4	5.2	SS26A	2	5.2	2.6	Y		
Sodium	4 / 5	15	110	51	SS26A	NA	NA	NA	N	103 - 221	Nutrient
Vanadium	14 / 14	1.7	30	14	SS31	2	15	7.1	Y	0.58 - 4.6	
Zinc	8 / 9	2.0	878	303	SS26A	50	18	6.1	Y	3.8 - 16.1	

* Lowest of the following: mean of all samples using one-half the detection limit for non-detects, or mean of detect samples only.

The HC50 values represent concentrations at which 50 percent of soil species or processes are supported; these values were thought to indicate acute effects.

Region IV saltwater surface water screening levels are used for comparison to constituents detected in surface water (Table 8-2) and groundwater. If no Region IV surface water screening values were available, we used the secondary chronic values (SCVs) calculated by the Oak Ridge National Laboratory (ORNL) (Suter and Tsao, 1996) are used, using methods developed by the USEPA (1995a) for the Great Lakes. The methods developed for calculating secondary, or Tier II, values were designed for instances where there were some acceptable toxicity data for a chemical, but not enough to satisfy the requirements for calculating water quality criteria, or Tier I values. "The Tier II methodology generally produces more stringent values than the Tier I methodology, to reflect greater uncertainty in the absence of additional toxicity data (USEPA, 1995a)." ORNL used methods similar to the USEPA's in qualifying toxicological data for inclusion in the Tier II calculations. Both the USEPA and ORNL used primarily effect level values from 48- and 96-hour acute tests to set secondary values. Chronic values are usually developed from acute values using acute:chronic ratios based on tests incorporating both types of endpoints and performed in a similar manner. Note, however, that the SCVs are freshwater values.

Ecological receptors are not likely to be directly exposed to groundwater. However, groundwater concentrations were compared to saltwater surface water screening values as a conservative evaluation of potential future surface water conditions. This method assumes that groundwater discharges to surface water with no dilution or contaminant attenuation. An evaluation of groundwater contaminant concentrations also allows for a better understanding of contaminant transport and complete exposure pathways.

Sediment screening values are also USEPA Region IV screening levels (Table 8-3). These are derived from statistical interpretation of effects databases and are generally based on observations of direct toxicity to invertebrates.

8.4.2 Food Chain Toxicity

Food chain effects are seen in wildlife, usually in response to chemicals that are more highly concentrated in food items than the media to which they are exposed. For chemicals that do not biomagnify, effects may be primarily based on substrate ingested incidentally with food or as a consequence of grooming. Food chain effect thresholds are usually reported as ingested doses. Evaluation of ingested doses requires selection of threshold toxicity values from studies of toxicants given to experimental animals. Because of their likely effect on population size, preference is given to reproductive or developmental effects in the selection process. Depending on the experimental outcome,

Table 8-2
Selection of Chemicals of Preliminary Concern - Surface Water
PSC 51

Remedial Investigation/Feasibility Study PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

[illegible]

Table 8-3
Selection of Chemicals of Preliminary Concern - Sediment
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Chemical	Frequency of Detection	Range of Detection (µg/kg)		Location of Maximum	USEPA Region IV Screening Level (mg/kg)	Maximum Hazard Quotient	Selected as a COPC?	Notes
		Min.	Max.					
Volatile Organics								
2-Butanone	1/3	5.7	5.7	D004	NA	NAppl	Y	
Toluene	1/3	0.69	0.69	D004	NA	NAppl	Y	
Notes:								
NA = Not Available								
NAppl - Not Applicable								
Min. = Minimum								
Max. = Maximum								

the results may include a NOAEL, a LOAEL, or both. In this assessment, both NOAELs and LOAELs were used to evaluate potential risk from food chain exposure. Threshold oral toxicity values for metals were taken from the ORNL study (Sample et al., 1996) and listed in Appendix K. NOAELs were used with maximum constituent concentrations, while LOAELs were used with mean concentrations, to provide a range of estimated risk for each receptor.

8.5 EXPOSURE ESTIMATE

Invertebrates and plants are assumed to be exposed directly to toxicants in the soil, and exposure is measured as the concentration of the toxicant in the soil. Likewise, potential contaminant exposure to life within the water column is measured by the concentration of the toxicant in surface water. Exposure of birds and mammals to soil contaminants occurs mainly through ingestion, and oral doses are estimated using ingestion rates, body weights, and contaminant concentrations in soil, using a food chain model.

For conservativeness at the screening step, maximum concentrations are used as exposure estimates for comparison to screening levels. Concentration ranges for all chemicals detected in surface soil are shown in Table 8-1, ranges for surface water are in Table 8-2, and ranges for sediment are in Table 8-3. Mean concentrations of chemicals detected in surface soil are also provided in Table 8-1, in order to help provide a broader basis for risk managers to decide whether further action is warranted at the site.

In order to assess potential hazards from groundwater seepage and discharge to surface water, maximum groundwater contaminant concentrations were screened against the USEPA Region IV surface water screening values. The chemical concentration ranges for groundwater are included in Table 8-4.

For the food chain modeling, exposure assessment includes the estimation of contaminant concentrations in soil and the rate at which they are ingested. Because the metals in soil at PSCs are not expected to biomagnify, concentrations in food items were not estimated in the food chain model. Exposure parameters used in the food chain models were derived from data in USEPA's Wildlife Exposure Factors Handbook (USEPA, 1993). USEPA's (2000c) Ecological Soil Screening Level Guidance was used for soil ingestion rates, which are given as a fraction of the food ingestion rate. Both conservative and average exposure values for ingestion rates and body weights were used to calculate oral dose. The derivation of these exposure parameters is presented in Appendix K. Food chain exposure, as an ingested dose, was calculated as follows:

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

[illegible]

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

NA = None Available
¹Used chronic screening values for salt water
 Min. = Minimum
 Max. = Maximum

$$\text{Daily intake (mg/kg-day)} = (C_f \times IR_f \times FI \times B) \times BW^{-1}$$

Where:

- C_f = concentration of contaminant in site substrate (mg/kg)
- IR_f = ingestion rate of substrate (kg/day); receptor-specific
- FI = fraction of intake from contaminated area (100 percent assumed)
- B = Bioavailability of contaminant (100 percent assumed for screening)
- BW = body weight of receptor (kg)

Two sets of exposure parameters, maximum and average variables, were used in this assessment to estimate receptor doses. Maximum exposure parameters are generally used in screening level risk assessments together with maximum detected constituent concentrations, to provide a conservative estimate of risk. The average exposure parameters were also used in order to provide a range of risk estimates.

8.6 RISK CALCULATION

In the screening assessment, risk is characterized by comparing maximum exposure concentrations to the USEPA Region IV screening guideline levels described in Section 8.6.1. In the food chain model, estimated doses of metals are compared to threshold toxicity doses to calculate risk. In both cases, the “quotient method” was used to describe risk. HQs were calculated by dividing the environmental concentrations for each COPC by their toxicity guidelines. For the food chain model, HQs were calculated by dividing mean doses by LOAELs and maximum doses by NOAELs.

HQs were not calculated for groundwater contaminants, since the groundwater screening is simply a conservative comparison of groundwater contaminant concentrations to surface water screening values.

A screening-level HQ (maximum concentration/guideline) less than 1.0 indicates that risk is unlikely to occur. An HQ greater than one indicates potential risk. Also, an HQ greater than one initiates a search for situations where areas with concentrations greater than guidelines are large enough for concern. Like the screening-level HQ, a NOAEL HQ less than 1.0 in the food chain modeling indicates unlikely risk.

The toxicity quotient method has some inherent limitations. Its primary limitation is that it relies on single estimates of exposure and toxicity. Maximum exposure concentrations are likely to overestimate the risk to ecological receptors. Likewise, if conservative toxicity values are used, then the risk calculation represents a “no/maybe” situation in which only the lack of risk has any certainty. If a threshold of likely risk is used for the toxicity value, then the calculation is a “yes/maybe” situation in which only the likely

risk result has any certainty. In other words, the quotient technique does not account for incremental toxicity. It also does not account for cumulative toxicity.

In this assessment, risk calculations are provided for the following five groups: VOCs, SVOCs, and metals. Each group will have information presented as an outline in the following order:

- Results of the surface soil screening: maximum substrate concentration versus Region IV toxicity guidelines. Comparisons of mean COPC concentrations to Region IV screening levels and alternate soil screening values (Dutch HC50). Emphasis is on the comparison of maximum values to Region IV guidelines.
- Results of the surface water screening: maximum concentrations versus Region IV screening levels for salt water environments.
- Results of the sediment screening: maximum concentrations versus Region IV screening levels.
- Results of the groundwater comparison: maximum concentrations versus Region IV screening levels for salt water environments.
- Food chain model results for vertebrates (birds and mammals – metals).
- The likely bioavailability or chemical form of a contaminant.

The lines of evidence were used to establish which chemicals were COCs. COCs were specified in a conclusion section for each chemical group in the following sections.

As just mentioned, VOCs and the COPC metals do not magnify in terrestrial food chains. Therefore, upper level predators are not likely to be at significant risk to these COPCs. Other pathways may not be complete. These will be discussed together with risk levels and bioavailability for chemical groups and individual COPCs in the sections to follow.

8.6.1 Volatile Organic Compounds

8.6.1.1 Surface Soil Screen

Five of the 13 constituents detected in surface soil had direct toxicity guidelines (Table 8-1). Of these five, only toluene had an HQ less than one. Both the mean and maximum hazard quotients for 1,2,3-trichlorobenzene were above unity, at 11 and 22, respectively. The mean and maximum HQs for naphthalene were 20 and 49, respectively. The mean (HQ = 9) and maximum (HQ = 54) concentrations of ethylbenzene were also above unity. The toxicity value for total xylenes was used to calculate direct risk for ortho-xylene and meta- and para-xylene. The mean and maximum concentrations for both xylenes exceeded the Region IV guideline. Maximum HQs were 198 and 98, for m- and p-xylene and o-xylene, respectively, while mean HQs were 36 and 18. The following eight VOCs had no soil toxicity guidelines, and, thus, could not be eliminated as potential concerns: hexachlorobutadiene, isopropylbenzene, n-butylbenzene, s-butylbenzene, 1,2,4-trimethylbenzene, 1,2,5-trimethylbenzene, p-isopropylbenzene, and n-propylbenzene.

As shown in Table 8-5, the Dutch HC50 value for aromatic solvents is 200 mg/kg. None of the VOCs present in site surface soils exceeds that level. In fact, if the maximum concentrations of all VOCs detected in site surface soil samples were summed, this concentration would still be less than the HC50 value. Therefore, acute effects to soil-dwelling organisms from VOCs are unlikely to occur at the levels detected on site.

8.6.1.2 Surface Water Screen

No HQs for COPCs in surface water exceeded one (Table 8-2). However, there is no Region IV ecological screening value for 2-butanone. The SCV (Suter and Tsao, 1996) for 2-butanone is 14,000 µg/L and the FDEP surface water cleanup criteria (FDEP Rule 62-777, Table I, August 5, 1999) is 120,000 µg/L. Therefore, 2-butanone is not carried forward as a COPC for surface water.

8.6.1.3 Sediment Screen

2-Butanone and toluene in sediment do not have Region IV ecological screening values, and are, thus, carried forward as COPCs for sediment (Table 8-3).

Table 8-5
Acute Surface Soil Guidelines
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

<i>Chemical</i>	<i>Dutch HC50 (2000)</i>	<i>Notes</i>
Volatile Organic Compounds		
Aromatic Solvents	200	
1,2,3-Trichlorobenzene		
1,2,4-Trimethylbenzene		
1,3,5-Trimethylbenzene		
Butylbenzene, n-	200	
Butylbenzene, s-	200	
Ethylbenzene		
Hexachlorobutadiene		
Isopropylbenzene		
Isopropyltoluene, p-		
Naphthalene		
Propylbenzene, n-		
Toluene	130	
Xylene, o-		value for total xylenes
Xylene, m- and p-		value for total xylenes
Semivolatile Organic Compounds		
1-Methylnaphthalene	40	value for total PAHs
2-Methylnaphthalene	40	value for total PAHs
Naphthalene	40	value for total PAHs
Metals		
Aluminum		
Antimony	2900	
Arsenic	40	
Barium	625	
Beryllium	30	
Cadmium	12	
Chromium	230	
Cobalt	240	
Copper	190	
Iron		
Lead	290	
Manganese		
Mercury	10	
Nickel	210	
Selenium	5	
Silver	15	
Vanadium	250	
Zinc	720	

8.6.1.4 Groundwater Screen

The analytical results of the groundwater samples indicated detection of 18 VOCs (Table 8-4). Nine of the 18 VOCs detected in groundwater had screening levels. Of these nine, only two COPCs (benzene and ethylbenzene) have maximum concentrations exceeding surface water guidelines. Benzene is present at a maximum concentration (120 µg/L), which is above its surface water toxicity guideline of 109 µg/L, and ethylbenzene's maximum of 20 µg/L is above its 4 µg/L guideline. Carbon disulfide, chloroform, 1,1,2,2-tetrachloroethane, 1,1-DCE, 1,2-dichloroethane, methylene chloride, and toluene are below their respective guidelines and are eliminated from further consideration.

There were no screening values for the remaining VOCs, but there were SCVs for 1,2-DCE, 2-butanone, 4-methyl-2-pentanone, acetone, chloromethane, TCE, vinyl chloride, and xylene (Table 8-4). SCVs are calculated according to USEPA protocol developed for the Great Lakes Initiative to conservatively estimate water quality guidelines for chemicals with insufficient data to develop water quality criteria (Suter and Tsao, 1996). Only xylene had a maximum value (20 µg/L) that exceeded its SCV (13 µg/L). No alternate screening values were found for bromodichloromethane, chloromethane, and vinyl chloride; they could not be excluded from potential concern.

8.6.1.5 Food Chain Model

VOCs were not included in the food chain modeling effort because they generally do not bioaccumulate.

8.6.1.6 Bioavailability

VOCs may be considered soluble in water and available for biological uptake, although losses to the atmosphere may be important in lowering actual exposures.

8.6.1.7 Conclusions

1,2,3-Trichlorobenzene, ethylbenzene, naphthalene, and xylenes were associated with risk to plants and invertebrates at the screening level in surface soil. However, the concentrations of these constituents are from data collected in 1998, and due to their volatility and their ability to biodegrade, these constituents are unlikely to be present at the same levels today. Several constituents had no available guidelines and, thus, could not be eliminated as COCs in surface soil. None of the VOCs present in site surface soils exceed the (acute) Dutch HC50 value for surface soil toxicity from aromatic solvents. Moreover, the maxima of all detected VOCs in site surface soil samples is less than the HC50 value. This, together with the NA of VOCs in surface soil, tends to minimize adverse effects to soil-dwelling organisms from VOCs at PSC 51.

The two VOCs present in sediment, 2-butanone and toluene, did not have screening guidelines and, thus, could not be eliminated as COPCs. Benzene and ethylbenzene were present in groundwater at concentrations above surface water guidelines. However, none of the VOCs detected in groundwater except 2-butanone, methylene chloride, and toluene were detected in site surface water samples. These chemicals are common to the types of products formerly handled at PSC 51, but each of them are common laboratory artifacts. In surface water, these three VOCs were present at levels below guidelines were not carried forward as COPCs. Thus, it is thought that the VOCs present in site groundwater are likely diluted, volatilized, or otherwise attenuated before or upon discharge to surface water. The absence in surface water of benzene, ethylbenzene, and most of the other VOCs in groundwater suggests that the groundwater pathway is not complete for volatile organic compounds.

The ability of the VOCs to volatilize and biodegrade may be important mechanisms for lowering exposures to ecological receptors. Therefore, it is unlikely that the VOCs present in site media are associated with unacceptable risk.

8.6.2 Semivolatile Organic Compounds

8.6.2.1 Surface Soil Screen

Three SVOCs were detected in site surface soil samples. Of these, only naphthalene had a Region IV screening guideline (Table 8-1). The maximum HQ for naphthalene was 6.5, while the mean HQ was 2. Recall that naphthalene was also detected using the protocol for volatile organic compounds, at higher concentrations than the SVOC results. 1-Methylnaphthalene and 2-methylnaphthalene had no screening levels and, thus, could not be eliminated as potential concerns. As shown in Table 8-5, the SVOCs, which are all PAHs, can be compared to an acute guideline (Dutch HC50) for total PAHs. The sum of the maximum values for these compounds is well below the 40 mg/kg guideline for total PAHs.

8.6.2.2 Surface Water Screen

SVOCs were not included in the surface water analysis.

8.6.2.3 Sediment Screen

SVOCs were not included in the sediment analysis.

8.6.2.4 Groundwater Screen

The groundwater screen indicated the presence of five SVOCs, four of which were PAHs (Table 8-4). Naphthalene was the only constituent that had a screening level (23.5 µg/L), which was exceeded by its maximum concentration of 31 µg/L. An SCV was located for 1-methylnaphthalene (2.1 µg/L), which was exceeded by its maximum concentration of 10 µg/L. The following contaminants had no screening levels and were carried forward: 2,4-dimethylphenol, 2-methylnaphthalene, and indeno(1,2,3-cd)pyrene.

8.6.2.5 Food Chain Model

SVOCs were not included in the screening-level food chain modeling effort because only a few PAHs were detected in surface soil at low parts-per-million levels. PAHs are a concern for bioaccumulation only at high substrate concentrations.

8.6.2.6 Bioavailability

SVOCs are generally not appreciably water-soluble and they tend to adhere to particulate matter in soil, and to suspended particles in the water column. Due to the physical characteristics of SVOCs, and their relatively low potential to biomagnify, the overall implication is that they are not highly available.

8.6.2.7 Conclusions

In general, the SVOC contamination on site does not appear to be widespread. Naphthalene in soil (Table 8-1) and naphthalene and 1-methylnaphthalene in groundwater (Table 8-4) were associated with potentially unacceptable levels of risk. A few compounds had no available guidelines, and thus could not be eliminated as COPCs. Although SVOCs were detected in groundwater, their concentrations and frequencies of detection were lower than VOC levels in groundwater. This follows from the greater tendency of SVOCs to be retained in soil. Because VOCs are unlikely to have a complete pathway to surface water at PSC 51, SVOCs are less likely to have a complete pathway.

8.6.3 Metals

8.6.3.1 Surface Soil Screen

The metals calcium, magnesium, potassium, and sodium had no available direct toxicity guidelines. These metals are nutrients that are toxic only at very high concentrations and, thus, are eliminated as a toxicity concern. The following metals had both mean and maximum concentrations exceeding Region IV surface soil toxicity guidelines: aluminum, antimony, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc (Table 8-1). Of these, maximum chronic HQs ranged from 5.2 for silver to 3,200 for chromium, while mean chronic HQs ranged from 2.6 for selenium and silver to 515 for aluminum. Arsenic and barium had maximum HQs greater than one ($HQ = 2$), while their mean HQs were less than one. Beryllium and cobalt had HQs less than one and, thus, are eliminated as surface soil COPCs.

Metal concentrations were also compared to the probable effects levels listed in Table 8-5. Cadmium, chromium, copper, lead, nickel, and zinc had maximum values exceeding their acute guidelines, while only copper had a mean value (2479 mg/kg) that exceeded its guideline (190 mg/kg). These results indicate that effects to soil organisms or plants may be expected from metals.

The metals levels were also compared to basewide background concentrations documented in the OU 1 RI/FS (ABB-ES, 1996); the maximum concentrations of all COPC metals exceeded their respective background screening concentrations. Consequently, these chemicals are carried forward.

8.6.3.2 Surface Water Screen

Metals were not included in the surface water analysis.

8.6.3.3 Sediment Screen

Metals were not included in the sediment analysis.

8.6.3.4 Groundwater Screen

The analytical results for groundwater samples indicated detection of 15 metals. Surface water screening levels were available for 5 of these contaminants: cadmium, chromium, copper, lead, and nickel. Of these, copper was the only metal whose maximum concentration in groundwater (8 µg/L) exceeded the screening value (2.9 µg/L).

8.6.3.5 Food Chain Model

Because the metal COPCs at PSC 51 do not biomagnify in terrestrial systems and because usage of the site for foraging is expected to be minimal, only incidental soil ingestion was modeled. For conservativeness, the smallest species that may be exposed were modeled, including the American robin, the short-tailed shrew, and the meadow vole (Table 8-6). Incidental soil ingestion factors (as fractions of food ingestion rates) for each species were the 50th percentile values calculated in USEPA's (2000c) soil screening level guidance:

meadow vole	0.0134
short-tailed shrew	0.0153
American robin	0.0668 (value for the woodcock)

The woodcock fraction was used for the robin because no value for the robin was found in the document. Using the most conservative comparison, maximum exposure/NOAEL, several metals have HQs that exceed one for each receptor (HQs up to about 420; Table 8-6). Using average exposures and LOAELs, there is potential risk to all receptors from aluminum (HQs from about 2 to 11), to the shrew and robin from copper (HQs of 1.4 and 3.2), and to the robin from chromium, lead, and mercury (HQs of about 3 or less).

8.6.3.6 Bioavailability

Aluminum and iron are among of the most abundant elements in the earth's crust, soil, and surface waters. They are usually bioavailable only at low pH (and high pH for aluminum). Since the pH of PSC 51 groundwater ranged from 5 to 7, it is expected that soil pH is in a similar range and aluminum and iron toxicity is not expected. The bioavailability of chromium, copper, lead, mercury, and other metals is variable in nature and not known for the site. However, it is unlikely to be 100 percent, as the direct toxicity comparisons and food chain models assume.

Table 8-6
Hazard Quotients for Ecological Receptors
Screening Level Ecological Risk Assessment
PSC 51

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Ecological Contaminant of Concern	Meadow Vole		Short-tailed Shrew		American Robin	
	NOAEL Max HQ ¹	LOAEL Mean HQ ²	NOAEL Max HQ ¹	LOAEL Mean HQ ²	NOAEL Max HQ ¹	LOAEL Mean HQ ²
Aluminum	405.02	5.8122	418.6	11.3	76.2	1.89
Antimony	3.687	0.05	3.81	0.106	NA	NA
Arsenic	1.33	0.01	1.4	0.013	0.73	0.021
Barium	0.62	0.0067	0.6	0.013	1.75	0.0152
Cadmium	0.24	0.002	0.24	0.0045	1.7	0.021
Chromium	3.9	0.067	3.98	0.13	135.2	3.26
Copper	6.2	0.701	6.37	1.37	16.4	3.23
Lead	1.47	0.013	1.52	0.025	111	1.7
Manganese	0.145	0.0087	0.15	0.017	0.137	0.0046
Mercury	1.67	0.04	1.72	0.07	89	1.7
Nickel	0.134	0.0087	0.14	0.017	0.74	0.121
Selenium	0.22	0.03	0.22	0.05	0.93	0.17
Silver	0.043	0.001	0.044	0.0019	NA	NA
Vanadium	1.40	0.03	1.45	0.06	0.28	0.0101
Zinc	0.054	0.00412	0.06	0.008	6.4	0.19

Notes:

NA - No toxicity reference value available

1 Calculated using conservative exposure parameters and maximum contaminant concentrations.

2 Calculated using average exposure parameters and mean contaminant concentrations.

8.6.3.7 Conclusions

Of the metals detected in site media, beryllium and cobalt were dropped from further consideration because no concentrations exceeded guidelines (Table 8-1). Copper had a maximum value in groundwater (8 µg/L) that was greater than the surface water screening level (2.9 µg/L); however, copper was detected in only one half of the groundwater samples. Because site copper levels in soil are high, the groundwater pathway does not appear to be complete. In soil, aluminum and iron were not likely to be bioavailable at site pH levels, so they were not retained as COPCs. Risk levels are potentially high for direct contact with metals in site soil, while wildlife risk is low or moderate when little usage of the site for foraging is assumed.

8.7 UNCERTAINTY

Once the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. Uncertainty is associated with all aspects of the Ecological Assessment methodology presented in the preceding sections.

Generally, risk assessments carry two types of uncertainty – measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. For example, this type of uncertainty is associated with analytical data used to characterize contaminant concentrations present in various environmental media; the risk assessment reflects the accumulated variances of the individual values used. Informational uncertainty stems from the limited availability of information needed to complete various portions of the assessment. Often this gap is significant; information regarding the effects of industrial chemicals on wildlife receptors, on the biological mechanism of action of a chemical, the impact physiological differences on exposure pathways or the behavior of a chemical in various environmental media (e.g., soil) is often absent.

Uncertainty is associated with each of the steps of the risk assessment process, including the following:

- Uncertainty in problem definition arises from ambiguities in characterization of contaminant sources and migration pathways, as well as in the exposure pathway analysis.
- Uncertainty associated with the exposure assessment includes the methods used and the assumptions made to determine exposure concentrations.

- Uncertainty in the ecological effects characterization includes the quality of the existing data to support a determination of potential adverse impacts to ecological receptors.
- Uncertainty in risk characterization includes that associated with the potential effects of exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

In these and other sources of uncertainty, the manner or direction (i.e., over or under prediction) in which assumptions affect the final predictions can sometimes be identified.

8.7.1 Uncertainty in Problem Definition

Uncertainty in the problem definition can arise as a result of contaminant source evaluation. Data gaps and incomplete or vague information regarding contaminant fate and transport (migration pathways) and the environmental receptors present and their local ecology may lead to uncertainty in determining complete exposure pathways. The community or population characteristics of soil organisms at the site are not known, and use of the site by wildlife is unknown. The assumption of little usage of the site is based on field observations of marginal plant cover and poor soil characteristics, such as a presumed lack of organic matter. Also, the presence of an overland transport pathway appears to be unlikely based on the site's flat topography and sandy soil, but this is not certain.

8.7.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises for the methods used to establish exposure point concentrations, gaps in the data, and bioavailability. Data collected for the site after interim measures were completed do not include metals and SVOCs in sediment and surface water. Per the RI Scope of Work prepared by the NAS Jacksonville Partnering Team, no radiological samples were collected for any media. Therefore, the degree to which the contaminant concentrations from these samples (and locations of these samples) represent the contamination at each site is uncertain. Contaminants may be present in forms that are toxic in varying degrees or differ in bioavailability. If it is assumed that measured concentrations are 100 percent bioavailable, the contaminant concentrations are likely to overestimate risk.

8.7.3 Uncertainty in the Ecological Effects Characterization

Ecological assessments must consider risks to many different species. However, calculation of risk values for each potential receptor species is not possible. For this assessment, conservative values, protective of a wide range of ecological receptors, were used for screening. The underlying assumptions

associated with the use of these values is that contaminant concentrations in excess of these guidelines are indicative of potential impacts to actual receptors inhabiting a given area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a contaminant are seldom known. The use of probable effects values for soil helps to ameliorate the uncertainty associated the use of screening levels.

Uncertainty in the results of the risk assessment process arises when extrapolations are made across levels of ecological organization, or from laboratory studies to field conditions in benchmark derivation. Typically the tested species are different from the species used as endpoints in the risk assessment. Also, the majority of the currently available toxicological data rests on the response of individuals exposed to chemicals. Extrapolations from these simple endpoints to more complex, ecologically relevant endpoints such as impacts to populations or communities introduce uncertainty into the results of the risk assessment. The uncertainty associated with extrapolations from results based on laboratory test conditions to field situations have long been acknowledged, but remains difficult to quantify.

8.7.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization includes the uncertainties associated with its design and components: problem formulation, exposure assessment, and effects characterization. Other sources of uncertainty emerge at the risk characterization step, such as not taking antagonistic or synergistic effects into account. Little or no information is available to determine the potential for antagonism or synergism for the chemicals of concern. Therefore, this uncertainty cannot be discussed in terms of its impact on the risk assessment, since it may either underestimate or overestimate potential ecological risk.

8.8 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The chemical data available for assessing PSC 51 are metals, SVOCs and VOCs in surface soil and groundwater, and VOCs in surface water and sediment. Maximum concentrations of aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc in surface soil exceeded screening levels for both background and ecological toxicity. The metals concentrations may be harming plants and soil organisms that reside at PSC 51, but should not pose a significant risk to wildlife, especially when the lack of suitable habitat at the site is considered.

There is considerable uncertainty regarding whether the groundwater-to-sediment/surface water pathway is complete for PSC 51. The three compounds that may form a link between these media are all common laboratory contaminants, and most of the VOCs detected in groundwater were not found in the unnamed

creek south of the site. Based on site topography, overland transport of contaminants appears to be unlikely. For chemicals measured in surface water and sediment with known toxicity, risk levels are low.

Risk managers for this site should bear in mind several factors. At best, PSC 51 is a marginal habitat. Site soils are sandy and are unlikely to provide suitable habitat for a variety of invertebrates. In addition, the site is only sparsely covered with grass and weeds. No trees or other types of cover exist on the site. Therefore, it is unlikely that vertebrate receptors would frequent the site, if at all. As a result, plants and invertebrates directly exposed to metals in soil appear to be at most risk. Of the metals, maximum cadmium, chromium, copper, lead, nickel, and zinc concentrations are elevated relative to probable effects levels.

Recommendations for PSC 51 depend in part on potential future uses. Transportation of the soil to other locations is not recommended, unless ecological exposure will not occur at the new location. Conclusions of acceptable risk are based on the assumption of little exposure. Any changes that may increase exposure, such as adding wildlife cover or amending the soil with organic matter, may increase risk and should be carefully considered. Maintained as it is now, the site does not appear to warrant further action.

9.0 DESCRIPTION OF THE FS

The FS, which is discussed in Sections 9.0 to 13.0 of this report, is the process for the development and decision of the remedial action to address the contamination at PSC 51. The following sections provide a detailed determination of the RAOs. After the RAOs are decided upon, a comparative analysis of remedial alternatives is performed to determine the best viable route for remedial activities.

The information that was provided by the RI on the extent and characteristics of contamination at PSC 51 is used in the FS. The additional information provided by the HHRA and ERA on the risks posed to human health and the environment by the existing site conditions provided additional data for the FS.

9.1 THE FS PROCESS

Development of remedial alternatives for CERCLA sites consists of a series of steps. The first step in the FS process is to develop RAOs. After the RAOs are developed then, applicable technologies are identified and those technologies are developed into remedial alternatives to meet the RAOs. The NCP requires that a range of alternatives be presented in the FS to the maximum practicable extent.

The first step in the FS process is to develop RAOs, which are media-specific goals established to protect human health and the environment. RAOs specify the contaminants of concern, media of interest, and exposure pathways, and are established such that a range of alternatives can be developed to achieve the objectives. RAOs for PSC 51 are developed in Section 10.0 and based on information provided from the RI and HHRA and ERA sections. Once RAOs are identified, general response actions for each medium of interest are developed. General response actions typically fall into the following categories: no action, containment, excavation, extraction, treatment, disposal, or other actions, singularly or in combination, which will satisfy the RAOs established for the site.

Section 11.0 discusses the process to identify and screen applicable technologies for each general response action. This step eliminates those technologies that cannot be implemented technically. Those technologies that pass the screening phase are then assembled into remedial alternatives. This FS report does not present information on alternatives that fail to meet the RAOs, except for a no action alternative, which provides a baseline for comparison of all alternatives.

Section 12.0 describes and analyzes in detail the remedial alternatives by using the seven criteria described in the NCP, including (1) overall protection of human health and the environment; (2) reduction of toxicity, mobility, or volume of contaminants through treatment; (3) compliance with ARARs; (4) long-term effectiveness and permanence; (5) short-term effectiveness; (6) implementability; and (7) cost.

Alternatives are evaluated against two additional factors after State participation and public comment period for the FS: (1) State acceptance and (2) community acceptance.

The results of the detailed analyses (for the first seven criteria) are summarized and compared in a comparative analysis (Section 12.0). The alternatives are compared against each other with the following criteria:

Threshold criteria:

- Overall protection of human health and the environment.
- Compliance with ARARs.

Primary balancing criteria:

- Cost effectiveness.
- Use of permanent solutions and alternative treatment technologies or resource recovery technologies, to the maximum extent practicable.
- Preference for treatment that reduces toxicity, mobility, or volume of contaminants as a principle element.

These criteria are used because Superfund Amendments and Reauthorization Act of 1986 (SARA) requires them TBC during remedy selection. Modifying criteria, which included State and community acceptance, are also evaluated. State acceptance is evaluated when the State reviews and comments on the draft FS report. A proposed plan is then considered based on the State's comments. Community acceptance is evaluated based on comments received on the FS and proposed plan during a public comment period. Comments from the community are addressed in a responsive summary in the Record of Decision (ROD), which documents the identification and selection of the remedy. The entire FS process provides the technical information and analyses that form the basis for a proposed plan and subsequent ROD.

9.2 REMEDIAL CONSIDERATIONS

Prior to establishing RAOs for PSC 51 it should be noted that NAS Jacksonville has not been listed on any base closure list by government officials (HLA, 2000). The installation is not expected to close at any time in the foreseeable future because the activities conducted by current tenants are well established and necessary to maintain the goals established for the installation by Navy officials.

10.0 REMEDIAL ACTION OBJECTIVES

This section presents the RAOs for PSC 51. The RAOs will provide the basis for selecting appropriate remedial technologies and developing remedial alternatives from those technologies for PSC 51. Section 10.1 presents the chemical-, location-, and action-specific ARARs that are considered prior to defining remedial alternatives for PSC 51. Section 10.2 presents an overview of various remedial considerations, such as regulatory drivers and risk issues that are evaluated prior to identifying the RAOs. Section 10.3 presents the RAOs for PSC 51.

10.1 ARARs

ARARs are Federal and State human health and environmental requirements used to (1) evaluate the appropriate extent of site cleanup, (2) scope and formulate remedial alternatives, and (3) control the implementation and operation of a selected remedial action. Potential chemical-, location-, and action-specific ARARs are defined and described in detail in the Handbook of ARARs for Navy Sites within the State of Florida (ABB-ES, 1995b). During the detailed analysis of remedial alternatives, each alternative will be analyzed to determine its compliance with ARARs. Chemical-, location-, and action-specific ARARs are presented on Table 10-1 and are discussed in the following subsections.

10.1.1 Chemical-Specific ARARs

Chemical-specific requirements are standards that limit the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels or the basis for calculating such levels. Chemical-specific ARARs for a site may also be used to indicate acceptable levels of discharge for determining treatment and disposal requirements and to assess the effectiveness of future remedial alternatives.

Currently, there are no promulgated Federal or State chemical-specific ARARs that provide limits for the concentration of chemicals in soil. The State of Florida does provide guidance values for SCTLs (FDEP, 1999), and Florida has indicated that these values should be considered TBC. The USEPA and the State of Florida have guidance documents for sediment quality criteria that can be considered TBCs for this FS. These criteria are listed in Table 10-1.

State and Federal chemical-specific ARARs are available for groundwater and include Federal MCLs and Florida drinking water standards. The State of Florida has classified groundwater at NAS Jacksonville as G-II, indicating that it is a potential future source of drinking water for the State.

Table 10-1
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Chemical-Specific ARARs				
Safe Drinking Water Act (SWDA) Regulations, Maximum Contaminant Levels (MCLs)	40 CFR Part 141	Relevant and Appropriate	Establishes enforceable standards for potable water for specific contaminants that have been determined to adversely affect human health.	Would be used as protective levels for groundwater or surface waters that are current or potential drinking water sources.
SDWA Regulations, National Secondary Drinking Water Standards (SMCLs)	40 CFR Part 143	To Be Considered	Establishes welfare-based standards for public water systems for specific contaminants or water characteristics that may affect the aesthetic qualities of drinking water.	Would be used as protective levels for groundwater or surface waters that are current or potential drinking water sources.
USEPA Office of Drinking Water, Health Advisories		Potential To Be Considered	Health advisories are estimates of non-carcinogenic risk due to consumption of contaminated drinking water.	These advisories would be considered for contaminants in surface water and groundwater that is or could be used as a potable water source.
Cancer Slope Factors (CSFs)		To Be Considered	CSFs are guidance value used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	CSFs would be considered for development of human health protection PRGs for soil and groundwater at this site.
Reference Doses (RFDs)		To Be Considered	RFDs are guidance values used to evaluate the potential noncarcinogenic hazard caused by exposure to contaminants.	RFDs would be considered for development of human health protection PRGs for soil and groundwater at this site.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
State Chemical-Specific ARARs				
Florida Drinking Water Standards	FAC Chapter 62-550	Applicable	Rule adopts Federal primary and secondary drinking water standards and also creates additional rules to fulfill State and Federal requirements for community water distribution systems.	These regulations would be used to determine cleanup levels for groundwater that is a potential source of drinking water.
Florida Surface Water Quality Standards	FAC Chapter 62-302	Potentially Applicable	Rule distinguishes surface water into five classes based on designated uses and establishes ambient water quality standards (called Florida Water Quality Standards) for listed pollutants.	Because these standards are specifically tailored to Florida waters, they should be used to establish cleanup levels rather than the Federal AWQC.
Florida Groundwater classes, Standards and Exemptions	FAC Chapter 62-520	Applicable	This rule designates the groundwater of the state into five classes and establishes minimum "free from" criteria. This rule also specifies that Classes I & II must meet the primary and secondary drinking water standards listed in Chapter 62-550.	These regulations would be used to determine cleanup levels for groundwater that is a potential source of drinking water.
Contaminant Cleanup Target Levels Rule	FAC Chapter 62-777	Applicable	This document provides guidance for soil, groundwater, and surface water cleanup levels that can be developed on a site-by-site basis.	These guidelines would be used in determining cleanup goals.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Location-Specific ARARs				
Endangered Species Act Regulations	50 CFR Parts 81, 225, 402	Potentially Applicable	This act requires Federal agencies to act to avoid jeopardizing the continued existence of federally listed endangered or threatened species.	If a site investigation or remediation could potentially affect an endangered species, these regulations would apply.
Historic Sites Act Regulations	36 CFR Part 62	Potentially Applicable	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	The existence of Natural Landmarks would be identified prior to remedial activities onsite including remedial investigations.
Fish and Wildlife Coordination Act Regulations	33 CFR Subsection 320.3	Potentially Applicable	Requires that the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and related state agencies be consulted prior to structural modification of any body of water, including wetlands. If modifications must be conducted, the regulation requires that adequate protection be provided for fish and wildlife resources.	If a remedial alternative involves the alteration of a stream or wetland, these agencies would be consulted.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Location-Specific ARARs				
National Environmental Policy Act (NEPA) Regulations, Wetlands, Floodplains, etc.	40 CFR Subsection 6.302 [a]	Potentially Applicable	These regulations contain the procedures for complying with Executive Order 11990 on wetlands protection. Appendix A states that no remedial alternative adversely affect a wetland if another practicable alternative is available. If no alternative is available, impacts from implementing the chosen alternative must be mitigated.	If remedial action affects a wetland, these regulations would apply.
National Environmental Policy Act (NEPA) Regulations, Floodplain Management, Executive Order 11988	40 CFR Part 6, Appendix A	Potentially Applicable	Appendix A describes the policy for carrying out the Executive Order regarding floodplains. If no practicable alternative exists to performing cleanup in a floodplain, potential harm must be mitigated and actions taken to preserve the beneficial value of the floodplain.	If removal actions take place in a floodplain, alternatives would be considered that would reduce the risk of flood loss and restore and preserve the floodplain.
Fish and Wildlife Conservation Act	40 CFR Section 6.302	Potentially Applicable	Requires action to be taken to protect fish and wildlife from projects affecting streams or rivers.	USFWS officials would be consulted on how to minimize impacts of any remedial activities on any wildlife.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Action-Specific ARARs				
Resource Conservation and Recovery Act (RCRA) Regulations, Identification and Listing of Hazardous Wastes	40 CFR Part 261	Potentially Relevant and appropriate for on-site TSD facility and Applicable for off-site TSD facility	Defines the listed and characteristic hazardous wastes subject to RCRA. Appendix II contains the Toxicity Characteristic Leaching Procedure.	These regulations would apply when determining whether waste onsite is hazardous, either by being listed or by exhibiting a hazardous characteristic, as described in the regulations.
Clean Air Act (CAA) Regulations, National Ambient Air Quality Standards (NAAQSs)	40 CFR Part 50	Potentially Relevant and appropriate for on-site TSD facility and Applicable for off-site TSD facility	Establishes primary (health-based) and secondary (welfare-based) air quality standards for carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur oxides emitted from a major source of air emissions. The NAAQSs form the basis for all regulations promulgated under the CAA. However, the NAAQSs themselves are non-enforceable and are not ARARs themselves.	Site remediation activities must comply with NAAQS. The principal application of these standards is during remedial activities resulting in exposures through dust and vapors. In general, emissions from CERCLA activities are not expected to qualify as a major source, and are therefore, not expected to be applicable requirements. However, the requirements may be determined to be relevant and appropriate for non-major sources with significantly similar emissions.
RCRA Regulations, Land Disposal Restrictions (LDRs)	40 CFR Part 268	Potentially Relevant and appropriate for on-site TSD facility and Applicable for off-site TSD facility	This regulation prohibits the land disposal of untreated hazardous wastes and provides criteria for the treatment of hazardous waste prior to land disposal.	Remedial actions that involve excavating, treating, and redepositing hazardous soil would comply with LDRs.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Action-Specific ARARs				
Clean Water Act (CWA), National Pollution Discharge Elimination System (NPDES)	40 CFR Parts 122 through 125, and 131	Potentially Relevant and Appropriate	NPDES (National Pollution Discharge Elimination System) permits are required for any discharges to navigable waters. If remedial activities include such a discharge, the NPDES standards would be ARARs.	Any alternative which would discharge into any navigable water would require compliance with these regulations including treatment, if necessary.
CAA National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR Part 61	Potentially Applicable	NESHAPs are a set of emissions standards for specific chemicals from specific production activities.	Emissions of hazardous air pollutants would be minimized by fugitive dust control and off gas treatment from the thermal desorption facility.
RCRA, Treatment Standards for Hazardous Debris - Thermal Desorption	40 CFR 268.45	Potentially Applicable	Sets treatment standards for using thermal desorption.	Any thermal desorption unit would be operated in compliance with treatment standards.
Air/Superfund National Technical Guidance	EPA Guidance: EPA/450/1-89/001- EPA/450/1-89/004	Potential To Be Considered	This guidance describes methodologies for predicting risks due to air release at a Superfund site.	These guidance documents would be considered when risks due to air releases from fugitive dust and thermal desorption are being evaluated.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Action-Specific ARARs				
Federal Facilities Compliance Act of 1992	HR 2194	Potentially Relevant and Appropriate	This act amends the Solid Waste Disposal Act to clarify provisions concerning the application of certain requirements to federal facilities, such as providing a conditional exception to RCRA's domestic sewage exclusion for federally owned treatment works (FOTWs). In general, it allows state agencies and the USEPA to enforce hazardous waste laws at government sites.	This act expands the domestic sewage exclusion policy to FOTWs. In addition, when wastewater is considered a hazardous waste under RCRA, but is mixed with domestic waste as it flows through the sewer system to the FOTW, the FOTW would not be required to meet the additional regulatory requirements for a RCRA facility.
OSHA Regulations, General Industry Standards	29 CFR Part 1910	Applicable	Requires establishment of programs to assure worker health and safety at hazardous waste sites, including employee training requirements.	These regulations would apply to all response activities.
OSHA Regulations, Occupational Health and Safety Regulations	29 CFR Part 1910, Subpart Z	Potentially Applicable	Establishes permissible exposure limits for workplace exposure to a specific listing of chemicals.	Standards are applicable for worker exposure to OSHA hazardous chemicals during remedial activities.
OSHA Regulations, Recordkeeping, Reporting, and Related Regulations	29 CFR Part 1904	Potentially Applicable	Provides record keeping and reporting requirements applicable to remedial activities.	These requirements apply to all site contractors and subcontractors and must be followed during all site work.
OSHA Regulations, Health and Safety Standards	29 CFR Part 1926	Potentially Applicable	Specifies the type of safety training, equipment, and procedures to be used during the site investigation and remediation.	All phases of the remedial response project would be executed in compliance with this regulation.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Action-Specific ARARs				
RCRA Regulations, Contingency Plan and Emergency Procedures	40 CFR 264, Subpart D	Potentially Relevant and Appropriate	Outlines requirements for emergency procedures to be followed in case of an emergency.	The administrative requirements established in this rule would be met for remedial actions involving the management of hazardous waste.
CAA Regulations, New Source Performance Standards (NSPS)	40 CFR Part 60	Potentially Relevant and Appropriate	This rule establishes NSPS for specified sources that are similar to a source that has established NSPSs (such as air stripping technologies). The NSPSs limit the emissions of a number of different pollutants, including the six criteria pollutants list (for which NAAQSs are established) as well fluorides, sulfuric acid mist, and total reduced sulfur (including hydrogen sulfide [H ₂ S]).	This rule may be a relevant and appropriate requirement for a new source that is similar to a source that has established NSPSs (such as air stripping technologies). If it is determined that the remedy would create potential air impacts, the response action or the equipment for the response action may qualify as a new source; therefore, these requirements would be met.
CWA Regulations, National Pretreatment Standards	40 CFR Part 403	Potentially Relevant and Appropriate	Sets pretreatment standards through the National Categorical Standards of the General Pretreatment Regulations for the introduction of pollutants from non-domestic sources into Publicly Owned Treatment Works (POTWs) in order to control pollutants that pass through, cause interference, or are otherwise incompatible with treatment processes at a POTW.	If groundwater is discharged to a POTW or the FOTW, the discharge must meet local limits imposed by the POTW. A discharge from a CERCLA site must meet the POTW's pretreatment standards in the effluent of the POTW. Discharge to a POTW is considered an offsite activity and is, therefore subject to both the substantive requirements of this rule.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Action-Specific ARARs				
RCRA Regulations, General Facility Standards	40 CFR Subpart B, 264.10-264.18	Potentially Relevant and Appropriate	Sets the general facility requirements including general waste analysis, security measures, inspections, and training requirements. Section 264.18 establishes that a facility located in a 100-year floodplain must be designed, constructed, and maintained to prevent washout of any hazardous wastes by a 100-year flood.	If the remedial action involves construction of an onsite treatment facility, such as a groundwater treatment facility, the substantive requirements of this rule would be applicable requirements. A permitted treatment facility must be selected for offsite treatment. These regulations do not apply to the aboveground treatment or storage of hazardous waste before it is injected into underground. However, this rule may be an applicable requirement for alternatives that do not involve groundwater reinjection.
RCRA Regulations, Miscellaneous Units	40 CFR Part 264, Subpart X	Potentially Relevant and Appropriate	These standards are applicable to miscellaneous units not previously defined under existing RCRA regulations. Subpart X outlines performance requirements that miscellaneous units be designed, constructed, operated, and maintained to prevent releases to the subsurface, groundwater, and wetland that may have adverse effects on human health and the environment.	The design of proposed treatment alternatives, not specifically regulated under other subparts of RCRA, must prevent the release of hazardous constituents and future impacts on the environment. This subpart would apply to onsite construction of any treatment facility that is not previously defined under the RCRA regulation.
RCRA Regulations, Preparedness and Prevention	40 CFR Part 264, Subpart C	Potentially Relevant and Appropriate	Outlines requirements for safety equipment and spill control for hazardous waste facilities. Facilities must be designed, maintained, constructed, and operated to minimize the possibility of an unplanned release that could threaten human health or the environment.	Safety and communication equipment would be incorporated into all aspects of the remedial process and local authorities would be familiarized with site operations.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Federal Action-Specific ARARs				
RCRA Regulations, Releases from Solid Waste Management Units (SWMUs)	40 CFR Part 264, Subpart F	Potentially Relevant and Appropriate	Establishes the requirements for SWMUs at RCRA regulated treatment, storage, and disposal (TSD) facilities. The scope of the regulation encompasses groundwater protection standards, point of compliance, compliance period, and requirements for groundwater monitoring.	These regulations would be followed for the treatment of hazardous waste.
RCRA Regulations, Standards for Owners and Operators of Hazardous Waste TSD Facilities	40 CFR Part 264	Potentially Relevant and Appropriate	Establishes minimum national standards defining the acceptable management of hazardous wastes for owners and operators of facilities that treat, store, or dispose of hazardous wastes.	If remedial actions involving management of RCRA wastes at an off-site TSD Facility or if RCRA wastes are managed onsite, the requirements of this rule would be followed.
RCRA Regulations, Use and Management of Containers	40 CFR Part 264, Subpart I	Potentially Relevant and Appropriate	Sets standards for the storage of containers of hazardous waste.	This requirement would apply if a remedial alternative involves the storage of a hazardous waste (i.e. contaminated groundwater) in containers, prior to treatment.
SWDA Regulations, Underground Injection Control Regulations	40 CFR Parts 144, 146, 147, and 1000	Potentially Relevant and Appropriate	Establishes minimum program and performance standards for underground injection programs. Technical criteria and standards for siting, operation, maintenance, reporting, and recordkeeping are included in Part 146. Also requires protection of underground sources of drinking water.	Discharge of treated groundwater, by well injection, would be in accordance with all criteria and standards in these regulations, as well as meet all State Underground Injection Control Program requirements. Treated groundwater would meet all SWDA standards for reinjection prior to well injection.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
State Action-Specific ARARs				
Florida Hazardous Waste Rules- October, 1993	FAC Chapter 62-730	Potentially Applicable	Adopts by reference sections of the Federal hazardous waste regulations and establishes minor additions to these regulations concerning the generation, storage, treatment, transportation and disposal of hazardous wastes.	These regulations would apply if waste onsite were deemed hazardous and needed to be stored, transported, or disposed of properly.
Florida Drinking Water Standards	FAC Chapter 62-550	Potentially Applicable	This rule adopts Federal primary and secondary drinking water standards.	These regulations would apply to remedial activities that involve discharges to potential sources of drinking water.
Florida Wetland Application Regulations- November, 1989	FAC Chapter 62-611	Potentially Applicable	Sets requirements for discharge of domestic wastewater to wetland. This rule mainly addresses the discharge of domestic wastewater to wetlands. Discharge limits are established for BOD, TSS, nitrogen, and phosphorous.	This rule would be considered for remedial alternatives that would result in discharges to wetlands where these limits may be approached.
Florida Wastewater Facility Permits	FAC Chapter 62-620	Potentially Applicable	This rule establishes requirements for wastewater permits. It was published in November 1994; however, it is not effective until Florida is recognized as a "delegated" state.	Upon delegation, facilities in Florida requiring a wastewater permit will meet the permitting requirements of this rule.
Florida Air Pollution Rules – October, 1992	FAC Chapter 62-2	Potentially Relevant and Appropriate	Establishes permitting requirements for owners of operators of any source that emits any air pollutant.	These requirements are appropriate for remedial action that could result in a release of regulated contaminants to the atmosphere, such as may occur during air stripping or excavation.
Florida Regulation of Stormwater Discharge – May 1993	FAC Chapter 62-25	Potentially Relevant and Appropriate	Establishes requirements for discharges of untreated stormwater to ensure protection of the surface water of the state.	Remedial actions would consider the impact of the discharge of untreated stormwater.

Table 10-1 (Continued)
Synopsis of Federal and State ARARs and Guidance Materials for PSC 51

Remedial Investigation and Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
State Action-Specific ARARs				
Florida Underground Injection Control Regulations – April, 1989	FAC Chapter 62-28	Potentially Applicable	Establishes a State Underground Injection Control Program consistent with federal requirements and appropriate to the hydrogeology of Florida.	These regulations would be considered if remedial actions involve underground injection.
Florida Ambient Air Quality Standards – December, 1994	FAC Chapter 62-272	Potentially Applicable	Establishes ambient air quality standards to protect human health and public welfare.	These ambient air quality standards would be met for remedial actions involving the possible release exposure of contaminants to the atmosphere.
Air pollution Episodes – September, 1994	FAC Chapter 62-273	Potentially Relevant and Appropriate	This rule classifies an air episode as an air alert, warning or emergency and establishes criteria for determining the level of the air episode. It also establishes response requirements for each level.	These regulations would be adhered to if remedial actions involve air emissions.
Florida Groundwater Permitting and Monitoring Requirements – April, 1994	FAC Chapter 62-522	Potentially Applicable	Establishes permitting and monitoring requirements for installations discharging to groundwater.	The substantive requirement for permitting would be met when discharge to groundwater is a possible remedial action. If these requirements are met under another permit, a separate discharge permit may not be required.
Florida Water Well Permitting and Construction Requirements – March 1992	FAC Chapter 62-736	Applicable	Establishes minimum standards for the location, construction, repair, and abandonment of water wells. Permitting requirements and procedures are established.	The substantive requirements for permitting would be met if remedial actions involve the construction, repair, or abandonment of monitoring, extraction, or injection wells.
Florida Rules on Hazardous Waste Warning Signs – July, 1991	FAC Chapter 62-736	Applicable	Requires warning signs at NPL and FDEP identified hazardous waste sites to inform the public of the presence of potentially harmful conditions.	This requirement will be met.
Florida Rules on Permits- November, 1994	FAC Chapter 62-4	Potentially Applicable	Establishes procedures for obtaining permits for sources of pollution.	These substantive requirements would be met during remediation.

Chemical-specific TBCs include the State SCTLs for sites in Florida and USEPA Region III RBCs.

Chemical-specific ARARs for surface water include the Florida surface water quality standards. Surface water in the St. Johns River has been classified as Class III water, indicating that it is primarily for recreation and propagation/maintenance of a healthy, well-balanced population of fish and wildlife (HLA, 1999b).

10.1.2 Location -Specific ARARs

Location-specific ARARs govern specific features of a site such as wetlands, floodplains, wilderness areas, and endangered species. Additionally, manmade features such as places of historical significance are also considered location specific ARARs. The location-specific ARARs place restrictions on concentrations of hazardous substances or the conduct of activities based on the site's particular characteristics or location.

At PSC 51, no wetlands, wilderness areas, or places of archaeological significance have been identified. There are no buildings located in the PSC 51 area, and therefore, there are no buildings of historical significance.

10.1.3 Action-Specific ARARs

Action-specific ARARs are technology or activity-based limitations controlling activities for remedial actions. Action-specific ARARs generally set performance or design standards, controls, or restrictions on particular types of activities. To develop technically feasible alternatives, applicable performance or design standards must be considered during the detailed analysis of remedial alternatives (Section 11.0).

Certain action-specific ARARs include permit requirements. Under CERCLA Section 121(e), permits are not required for remedial actions conducted entirely on site at Superfund sites. This permit exemption applies to all administrative requirements, including approval of or consultation with administrative bodies documentation, record keeping, and enforcement. However, the substantive requirements of these ARARs must be attained. Action-specific ARARs are identified in Table 10-1.

10.1.4 TBC Criteria

TBCs are Federal and State nonpromulgated advisories or guidance that are not legally binding and do not have the status of being a potential ARAR. If there are no specific regulatory requirements for a chemical or site condition, or if ARARs are deemed insufficiently protective, then guidance or advisory

criteria should be identified and used to ensure the protection of human health and the environment. TBCs are identified in Table 10-1.

10.2 IDENTIFICATION OF RAOs

RAOs are defined in the CERCLA RI/FS guidance manual as media-specific goals that are established to protect human health and the environment (USEPA, 1988). The RAOs are typically based on COPCs, exposure routes, and receptors present or available at the site. RAOs are identified for PSC 51 by medium and are considered based on results of the RI, the HHRA, the ERA, and the ARARs, and the TBCs listed in Table 10-1.

For this FS, RAOs are identified for a medium in which:

- There exists a potential risk, as predicted in the HHRA (Section 7.0) or the ERA (Section 8.0).

And/or

- There exists chemical exceedances of the defined ARAR or TBC values (refer to Subsection 10.3.1 for these ARARs and TBCs).

10.2.1 RAOs for Soil

Several soil samples were collected at PSC 51 during previous investigations and the RI. The analytical results of soil data were detailed in Sections 3.0 and 5.0 of this report.

As stated in Subsection 10.1.1, there are no promulgated Federal or State chemical-specific ARARs that provide limits for the concentration of chemicals in soil at PSC 51. However, the State of Florida has provided SCTLs for sites in Florida (FDEP, 1999) and has indicated that these values should be used when evaluating surface soils.

A previous soil removal from the ODA and FFTA (BEI, 1999) was performed mitigating the potential for continued impacts from the sources to groundwater from leaching.

Results of the RI indicate that surface soil constituents exceeding SCTLs from the ODA were arsenic and vanadium. The vanadium concentration slightly exceeded the FDEP residential SCTL, and the NAS Jacksonville basewide background concentration. The vanadium concentration did not exceed the USEPA Region III residential RBC or the FDEP industrial SCTL. Vanadium was evaluated in the risk assessments and not retained as a COPC.

Arsenic was detected at concentrations exceeding both the FDEP residential and industrial SCTLs. Of the 18 surface soil samples collected at the ODA, eight samples exceeded the FDEP residential SCTL. Two samples, S004 (3.7 mg/kg) and SS07 (4.3 mg/kg), exceeded the FDEP industrial SCTL. The results for S004 did not exceed the USEPA industrial value, but the sample from SS07 did exceed the USEPA industrial value. Table 10-2 provides a summary of exceedances of ARARs/TBCs for surface soil.

Results of the RI indicate that surface soil constituents exceeded FDEP SCTLs from the FFTA. Ten metals were detected at concentrations exceeding the FDEP residential SCTL. The metals were aluminum, antimony, arsenic, barium, copper, iron, lead, mercury, nickel, and vanadium. Two of the metals detected at the FFTA exceeded the FDEP industrial SCTLs. The metals were arsenic and lead. Arsenic was detected at a concentration of 6.1 mg/kg from the surface soil sample at SS22 in excess of the FDEP industrial SCTL of 3.7 mg/kg. Lead was detected at SS22 (1130 mg/kg) and SS26A (1190 mg/kg) in excess of the FDEP industrial SCTL of 920 mg/kg.

Two metals, antimony and nickel, exceeded the FDEP leachability SCTLs. However, since the media of concern is surface soil, and nickel and antimony were not detected at significant concentrations in nearby monitoring wells, the leachability SCTL are removed from further consideration.

A risk assessment was conducted for surface soil at PSC 51 from the initial four samples collected at the ODA. The current and future exposure scenarios evaluated for surface soil are indicated in Section 7.0. As stated in Section 7.0 COPCs were selected if the detected concentration of a chemical exceeded the risk-based screening criteria. Other considerations for selecting COPCs are discussed in Section 7.2.

As discussed in Section 7.0 the results of the additional 14 surface soil samples collected at the ODA in Fall 2001/Winter 2002 and the 12 surface soil samples collected in the FFTA were reviewed to determine if the HHRA may require modification. Arsenic was detected at a maximum concentration of 4.3 mg/kg in the new samples from the ODA and 6.1 mg/kg in the samples from the FFTA as compared to a maximum concentration of 3.7 mg/kg in the original samples. The HHRA determined that the conclusions of the HHRA pertaining to arsenic would not significantly change if the new soil data was included. Cancer risks resulting from exposures to arsenic in soil for all receptors were within USEPA's target risk range of 10^{-4} to 10^{-6} , but exceeded FDEP's target risk level of 1×10^{-6} for residential exposures. The cancer risks resulting from exposures to arsenic in soil would be slightly lower if the new soil data was included in the risk assessment. The maximum detected arsenic concentration of 3.7 mg/kg was used as the exposure point concentration in the risk assessment since there were an insufficient number of samples to calculate an UCL. Based on the new data, the UCLs of 1.68 mg/kg for the ODA and 2.98 mg/kg for the FFTA are less than the exposure point concentration of 3.7 mg/kg. Consequently, the cancer risks were

determined to be lower if the new data was used in the risk assessment, although the risks for residential exposures would still exceed 1×10^{-6} .

Table 10-2
Summary of Exceedances of ARARs/TBCs for Surface Soil

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Analyte	Frequency of Detection	Range of Detected Concentrations	Mean of Detected Concentrations	Maximum Detected Concentration	FDEP SCTLs Res/ind/leach
<u>Inorganics (mg/kg)</u>					
<u>ODA</u>					
Arsenic	17/18	0.24 to 4.3	1.45	4.3	0.8/3.7/29
Vanadium	4/4	1.8 to 15.1	137.1	209	15/7400/980
<u>FFTA</u>					
Aluminum	8/8	1460 to 79200	36536	79200	72,000/*/**
Antimony	7/8	0.7 to 46.7	17.87	46.7	26/240/5
Arsenic	10/12	1.1 to 6.1	2.59	6.1	0.8/3.7/29
Barium	8/8	9.6 to 319	117.1	319	110/87000/1600
Copper	12/12	11 to 7310	2478.8	7310	110/76000/**
Iron	8/8	350 to 40400	19055	40400	23000/480000/**
Lead	11/11	4.2 to 1130	451.4	1130	400/920/**
Mercury	5/5	0.02 to 5.4	1.85	5.4	3.4/26/2.1
Nickel	12/12	3.1 to 544	160.3	544	110**/28000/130
Vanadium	10/10	1.7 to 29.8	16.69	29.8	15**/7400/980

Notes: *Contaminant is not a health concern for this scenario.
 **Direct exposure value based on acute toxicity.
 ***Leachability values may be derived using SPLP Test to calculate site-specific SCTL.
 NL = None Listed.

Also as stated in the HHRA, in addition to arsenic, several noncarcinogenic metals were detected at concentrations that exceeded USEPA Region III RBCs (aluminum, antimony, chromium, and copper) and FDEP SCTLs (aluminum, antimony, barium, chromium, copper, iron, lead, mercury, nickel, and vanadium) for residential exposures. The concentrations of lead exceeded the FDEP SCTL for industrial exposures at two locations, although, the 95 percent UCL of 685 mg/kg is less than the industrial SCTL of 920 mg/kg. It should be noted that the SCTLs for barium, copper, nickel, and vanadium are based on acute exposures to children exhibiting soil pica ingestion, which is not a typical exposure scenario. The HHRA summarized that since concentrations of these chemicals exceeded the residential RBCs and SCTLs, it is possible that hazard indices for residential exposures may exceed acceptable levels if the new soil samples were evaluated in the HHRA.

The results of the HHRA indicate arsenic as a COPC for the ODA and FFTA and potential residential risks from the noncarcinogenic metals at the FFTA, which may exceed HIs.

An ecological assessment of PSC 51 was performed assessing the metals in surface soil. The ERA determined that maximum concentrations of aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc in surface soil exceeded screening levels for both background and ecological toxicity. The metals concentrations may be harming plants and soil organisms that reside at PSC 51, but should not pose a significant risk to wildlife, especially when the lack of suitable habitat at the site is considered. As a result, plants and invertebrates directly exposed to metals in soil appear to be at most risk. The ERA summarized that PSC 51, maintained as it is now, does not appear to warrant further action.

Based on the results of the HHRA, and the exceedance of ARARs, an RAO will be established for surface soil at PSC 51. The HHRA predicted arsenic was a risk to human health, and aluminum, antimony, barium, chromium, copper, iron, lead, mercury, nickel, and vanadium may be a risk for residential scenarios if fully evaluated. The following RAO will be established for these COPCs in surface soil at PSC 51.

Surface Soil RAO: Protect human health by eliminating or preventing exposure to COCs in soil.

10.2.1.1 Soil Chemicals of Concern and Preliminary Remedial Goals (PRGs)

PRGs have been developed for this FS to provide a quantitative mechanism for determining when the RAOs have been achieved. The purpose of this section is to present the applicable soil COPCs and the associated soil PRGs. In determining soil COPCs, selection criteria were based on contaminant concentrations exceeding FDEP SCTLs and results of the HHRA and ERA. For this FS, FDEP SCTLs will serve as the soil PRGs partly because promulgated ARARs for surface soil are not available. Chromium was removed from the PRG list because the FDEP SCTLs for chromium is for hexavalent chromium.

Soil COCs and PRGs for PSC 51 are:

Chemical of Concern	PRG (Residential/Industrial, mg/kg)
Arsenic	0.8/3.7
Lead	400/920
Vanadium	15/7400
Aluminum	72,000/*
Antimony	26/240
Barium	110/87000
Chromium	210/410
Copper	110/76000
Iron	23000/480000
Mercury	3.4/26
Nickel	110/28000

* Contaminant is not a health concern for this scenario.

10.2.2 RAOs for Surface Water

Four surface water samples were collected at PSC 51 and analyzed for VOCs. During the RI, surface water samples were collected from the unnamed creek adjacent to PSC 51. Results of the RI indicate VOC contamination of the surface water, including one detection of 2-butanone at 0.7 µg/L; three detections of methylene chloride at 0.71, 0.65, and 0.66 µg/L; and two detections of toluene at 0.11 and 0.15 µg/L. No other VOCs were detected. It should be noted that 2-butanone and methylene chloride are common laboratory contaminants.

Chemical-specific ARARs for surface water include the Florida surface water standards (refer to Subsection 10.1.1). A comparison of site data to these standards indicated that concentrations in the surface water samples did not exceed FDEP surface water criteria.

An HHRA was completed for human exposure to surface water. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 7-4. The concentrations of all chemicals in surface water were less than the risk-based COPC screening levels. Consequently, there were no human health COPCs identified for surface water at PSC 51.

An ecological assessment was conducted for aquatic receptor exposure to surface water at PSC 51. As mentioned in the ERA summary, there is considerable uncertainty regarding whether the

groundwater-to-sediment/surface water pathway is complete for PSC 51. For the chemicals measured in surface water with known toxicity, risk levels are low.

Although COPCs did not exceed surface water criteria and are currently not a risk, as indicated in Section 2.0 it was determined that the groundwater at PSC 51 discharges into the unnamed creek. Consequently, it is expected that the potential exists for dissolved contaminants in groundwater (primarily VOCs) to discharge to the surface water in the unnamed creek. Therefore an RAO will be established for surface water at PSC 51 to assure that human and/or ecological receptors are not exposed to this medium, should contaminants discharge to the creek. The following RAO will be established for surface water:

Surface Water RAO: Protect Human Health and the Environment by preventing potential exposure to COPCs in surface water.

10.2.2.1 Surface Water COPCs and PRGs

In order to establish a method of action for surface water monitoring and a contingent action in case groundwater COCs discharge at concentrations greater than ARARs/TBCs the following steps were performed.

The first step is to determine the set of chemicals in groundwater most likely to discharge to surface water. This was accomplished by reviewing the list of chemicals detected in groundwater in the down-gradient areas of PSC 51. The three constituents previously detected in surface water are also included on the list.

The second step is to select a set of criteria (e.g., the selection criteria) that may be appropriate for the anticipated site use (e.g., ARARs and TBCs discussed in subsection 10.1.1). Florida ARARs/TBCs were used when possible because the State ARARs/TBCs are specifically tailored for Florida waters. For surface water, the selection criteria area as follows:

- Florida Surface Water Quality Standards (SWQS), FAC 62-302.
- If a chemical did not have a Florida SWQS, the Freshwater Surface Water Cleanup Target Levels from FAC 62-777 were used.
- If a chemical did not have a criteria listed from either of the above, then the National Recommended Water Quality Criteria for Priority Toxic pollutants was used.

PRGs have been developed for surface water in this FS due to the potential for future contaminant impact to surface water. The purpose of this selection is to present the applicable surface water COPCs and the associated surface water PRGs. The establishment of surface water PRGs provides a list of chemicals for future monitoring of surface water, and an established numerical value for future contingent action should COPCs exceed PRGs. Surface water COPCs were selected based on previously detected contaminants in surface water and contaminants detected in down-gradient monitoring wells.

Surface water COPCs and PRGs for PSC 51 are:

Chemical of Concern	PRG (µg/L)
2-Butanone	120,000
Methylene chloride	<1,580 annual avg.
Toluene	475
Benzene	<71.28 annual avg.
1,2-DCE	7,000
Ethylbenzene	605
Trichloroethene	<80.7 annual avg.
Vinyl Chloride	525
Xylenes	370
Naphthalene	26

The Class III Predominantly Fresh Water Classification was used from the Chapter 62-302 SWQS for benzene, methylene chloride, and TCE. The Freshwater Surface Water Criteria was used from the Chapter 62-777 for 2-butanone, ethylbenzene, 1-2 DCE (mixture), naphthalene, toluene, and xylenes. The National Recommended Water Quality Criteria for Priority Toxic Pollutants was used for vinyl chloride. The Human Health For Consumption of Organism classification was used for the vinyl chloride PRG due to the absence of a freshwater value.

10.2.3 RAOs for Groundwater

Groundwater at PSC 51 was sampled and analyzed during the RI and the analytical results are discussed in Section 5.0 of this report. Chemical specific ARARs established for groundwater were identified in Subsection 10.1.1, and a comparison of these established ARARs was performed for the groundwater analytical results at PSC 51 in the RI. The comparison indicated that the concentrations of several chemicals in groundwater exceeded their respective ARARs. Table 10-3 presents a summary of exceedances of ARARs/TCBs for groundwater.

The HHRA completed for groundwater at PSC 51 evaluated risks from the analytical results from the groundwater samples collected at PSC 51. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 7-5. The following chemicals were detected at maximum concentrations that exceeded the risk-based COPC screening levels:

- VOCs - 1,1-DCE, 1,2-dichloroethane, 1,2-DCE, benzene, bromodichloromethane, chloroform, TCE, and vinyl chloride
- SVOCs - 2-methylnaphthalene and naphthalene

Maximum detected concentrations of aluminum, antimony, arsenic, cadmium, iron, and manganese exceeded the screening criteria but were within background concentrations, consequently these chemicals were not retained in the HHRA, and will not be carried into the FS. The results of the HHRA are the incremental lifetime cancer risks for the hypothetical future adult resident exposed to groundwater exceeded USEPA's target cancer risk range and FDEP's target cancer risk level. Benzene, 1,1-DCE, and vinyl chloride were the main contributors to the cancer risk in groundwater.

An ecological risk assessment was also conducted for groundwater at PSC 51. ERA did not identify any risk associated with the groundwater contamination. It did report considerable uncertainty regarding the groundwater to surface water pathway, however.

An RAO will be established for the contaminant concentrations located in groundwater. Although the SVOCs, naphthalene and 2-methylnaphthalene, exceeded their respective ARARs, the primary contaminant exceedances are from the VOCs benzene, vinyl chloride, and 1,2-DCE. Additionally, the benzene, vinyl chloride, and 1,1-DCE were determined from the HHRA to be the main contributors to the cancer risk in groundwater. As a result of the HHRA and the ARAR exceedances, the RAO for groundwater will be driven by these primary VOCs detected. Two RAOs have been developed for groundwater, one as a result of the risks to human health, and the second due to the exceedance of ARARs. The following RAOs have been developed:

Groundwater RAO 1: Reduce human health risk associated with exposure to groundwater at PSC 51 due to various organic compounds (e.g., 1,1-DCE, benzene, and vinyl chloride).

Groundwater RAO 2: Reduce groundwater contamination at PSC 51 to meet chemical-specific ARARs.

10.2.3.1 Groundwater COPCs and PRGs

In order to establish action levels for contaminated groundwater at PSC 51, the first step is to determine the set of chemicals associated with the site groundwater. This was accomplished by listing all chemicals detected in groundwater at PSC 51.

The second step is to select a set of criteria (e.g., the selection criteria) that may be appropriate for the anticipated site use (e.g., ARARs and TBCs discussed in Subsection 10.1.1). For groundwater, the selection criteria are as follows:

- The Florida GCTLs taken from FDEP 62-777, FAC, August 1999.
- If a chemical did not have a Florida GCTL, then the Federal MCL (if available) was used.
- or
- If a chemical did not have either of the above criteria, then the higher value of the Florida GGC and the USEPA Region III RBC was used.

Note: All chemicals of concern have a Florida GCTL, thus these action levels will be used.

The third step in identifying action levels for groundwater at PSC 51 was to compare the concentrations of chemicals detected to the corresponding selection criteria. If a maximum concentration of a chemical was greater than the appropriate selection criterion, then the chemical was considered a COPC for this FS. The comparison shows that groundwater contains detection of chemicals at concentrations greater than the selected criteria.

For the purpose of this FS, the selection criteria were considered the action levels for remedial action for groundwater at PSC 51. Table 10-3 presents a summary of the chemicals exceeding the selected criteria for groundwater.

PRGs have been developed for groundwater in this FS due to the exceedances in contaminant concentrations discussed above. The purpose of this section is to present the applicable groundwater COPCs and the associated groundwater PRGs. Groundwater COPCs were selected based on contaminant concentrations exceeding FDEP GCTLs and results of the HHRA and ERA. In developing groundwater PRGs, the VOC COPCs have an assigned FDEP GCTL, which will be used as the PRG.

Table 10-3
Summary of Exceedances of ARARs/TBCs for Groundwater

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Analyte	Frequency of Detection	Range of Detected Concentrations	Mean of Detected Concentrations	FDEP GCTLs	USEPA MCLs
<u>Volatiles (µg/L)</u>					
1,2-DCE (mix)	8/14	0.94 to 64.0	10.72	63	NL
cis-1,2-DCE	24/80	1.3 to 110.0	19.9	70	70
Benzene	31/94	1.0 to 240.0	25.95	1	5
Ethylbenzene	12/94	0.17 to 85.0	13.95	30	700
Toluene	9/94	1.0 to 470.0	40.48	40	1000
TCE	20/94	0.097 to 78.0	8.48	3	5
Vinyl Chloride	14/94	1.5 to 37.3	6.55	1	2
Xylenes (Total)	13/94	1.0 to 380.0	35.73	20	10000
<u>Semivolatiles (µg/L)</u>					
2-Methylnaphthalene	1/14	20.0	20.0	20	20
Naphthalene	24/94	1.0 to 120	16.12	20	NL
<u>PAHs (µg/L)</u>					
Naphthalene	3/14	0.69 to 30.0	10.7	20	NL
<u>Inorganics (µg/L)</u>					
Aluminum	11/14	109 to 3,190	734.7	200	NL
Iron	14/14	154 to 5,560	1,462.4	300	NL
Manganese	11/14	14.3 to 119	44.61	50	NL
<p>Notes:</p> <p>1) Frequency of detection is the number of confirmatory samples in which the analyte was detected versus the total number of confirmatory samples analyzed from both the validated and mobile laboratory analytical data.</p> <p>2) The mean of detected concentrations is the arithmetic mean of all confirmatory samples in which the analyte was detected. It does not include the confirmatory samples in which the analyte was not detected.</p> <p>GCTLs taken from FDEP 62-777, FAC, August 1999.</p> <p>MCL taken from USEPA Drinking Water Regulations and Health Advisories.</p> <p>NL – Not listed</p>					

Groundwater COPCs and PRGs for PSC 51 are:

Chemical of Concern	PRG (µg/L)
1,2-DCE (mixture)	63
1,1-DCE	7
Benzene	1
TCE	3
Vinyl Chloride	1
Ethylbenzene	30
Toluene	40
Xylenes	20
Naphthalene	20

10.2.4 RAO for Sediment

As indicated in Section 4.0, three sediment samples analyzed for TCL VOCs were collected in the unnamed creek located downgradient of PSC 51. VOCs detected in the sediment samples include one detection of 2-butanone at 5.7 µg/L and one detection of toluene at 0.69 µg/L. No other VOCs were detected in the sediment samples. The detected contaminant concentrations in the sediment samples did not exceed the FDEP sediment criteria.

A HHRA was also conducted based on the results of the sediment samples collected at PSC 51. A comparison of the maximum detected concentrations of all chemicals in sediment was less than the risk-based COPC screening levels. Consequently, there were no COPCs identified for sediment at PSC 51.

An ERA was conducted for sediment samples collected from the unnamed creek. This assessment indicated there is considerable uncertainty regarding whether the groundwater to sediment/surface water pathway is complete for PSC 51. The compounds that may form a link between these media are all common laboratory contaminants, and most VOCs detected in groundwater were not found in the stream south of the site. For chemicals measured in the sediment with known toxicity, risk levels are low.

No RAO will be established for sediment at PSC 51 because no risks were predicted for human or ecological receptors based on exposure to this medium, and ARARs were not exceeded. Due to this, no sediment COPCs or PRGs will be selected or developed for sediment at PSC 51.

10.2.5 Summary of RAOs

The RAOs identified for PSC 51 will address contamination of metals in the surface soil and VOCs and naphthalene in groundwater. Table 10-4 summarizes the RAOs developed for PSC 51.

TABLE 10-4
Summary of Remedial Action Objectives for PSC 51

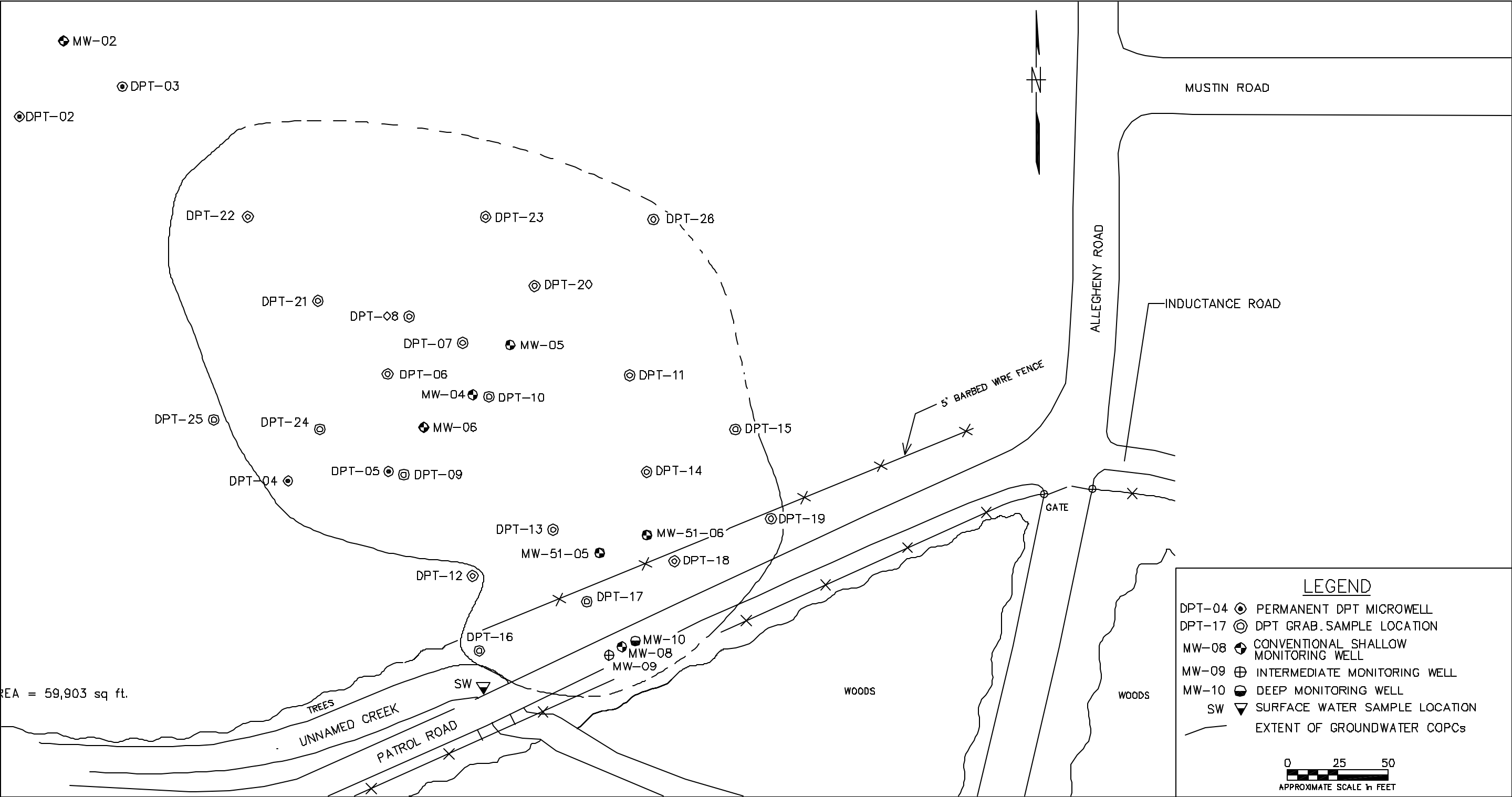
Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida


Remedial Action Objective	Description
RAO 1	Protect human health by eliminating or preventing exposure to COPCs in soil.
RAO 2	Protect Human Health and the Environment by preventing potential exposure to COPCs in surface water.
RAO 3	Reduce human health risk associated with exposure to groundwater at PSC 51 due to various organic compounds (e.g., 1,1-DCE, benzene, and vinyl chloride).
RAO 4	Reduce groundwater contamination at PSC 51 to meet chemical-specific ARARs.

10.3 ESTIMATED AREAL EXTENT AND VOLUME OF CONTAMINATED MEDIA

The aerial extent and volume of contaminated soil and groundwater at PSC 51 has been determined from the surface area and depth of both media of concern.

A conservative estimate for the volume of contaminated groundwater was calculated to be approximately 3,920,651 gallons. This is based on the surface area of the plume from Figure 10-1 [59,903 square ft (ft²)], plume thickness (35 ft²), and an assumed porosity of 0.25. The estimated total mass of soluble hydrocarbon contaminants is 1.28 pounds (lbs). The estimated total mass of adsorbed hydrocarbon contaminants is 10.54 lbs. The total estimated mass of hydrocarbons in the saturated zone is estimated to be 11.82 lbs. Further computations concerning the mass of dissolved and adsorbed contaminants are presented in Appendix L.

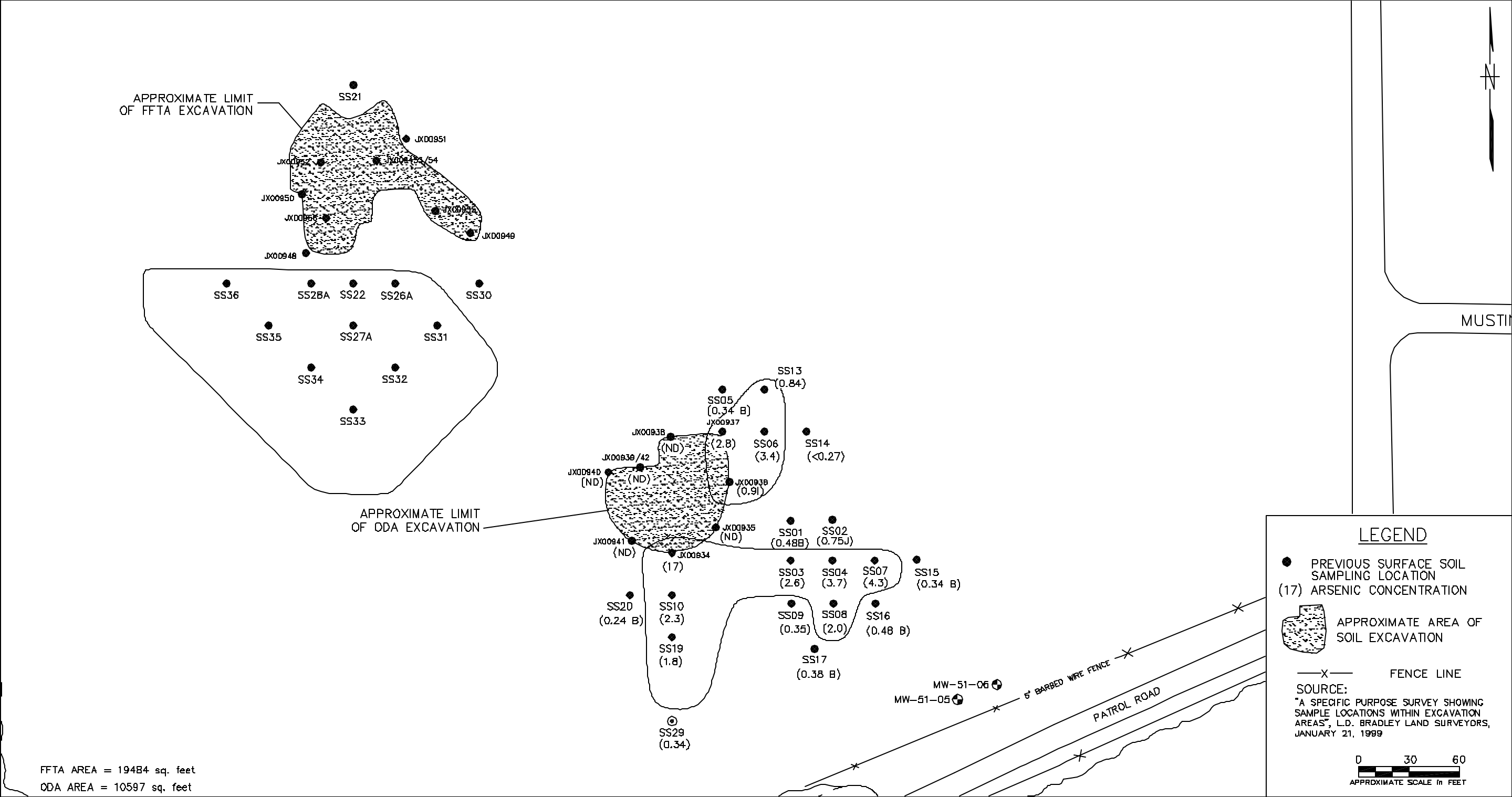



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		ESTIMATED EXTENT OF GROUNDWATER COPCs PSC 51 NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. N0253	
							JDF	1/23/02			APPROVED BY	DATE
							CHECKED BY	DATE			APPROVED BY	DATE
							COST/SCHED—AREA				DRAWING NO.	REV.
							SCALE		FIGURE 10—1		0	
							AS NOTED					

The volume of contaminated soil was determined to be approximately 1,560 tons of soil. This is based on an estimated surface area of contaminants from Figure 10-2 (FFTA 19,484 ft²; ODA 10,597 ft²) and a thickness of 1 ft. To produce an estimate of contaminated soil for the FFTA, an assumption was made to step out 50 ft from the exterior sampling points with metal concentrations exceeding FDEP residential SCTLs. This was done for a conservative estimate since the delineation of metals concentrations was completed to FDEP industrial SCTLs. Prior to any removal action, additional soil delineation will be required to determine the exact extent of soil COCs above FDEP residential SCTLs for excavation purposes. Calculations for the volume of contaminated soil are presented in Appendix L.

10.4 GENERAL RESPONSE ACTIONS

General response actions describe potential medium-specific measures that may be employed to address RAOs. Potential response actions at PSC 51 are developed for groundwater, surface water, and surface soil, and are discussed in more detail in Section 11.0. The response actions include no action, limited action, containment, disposal, removal, in-situ treatment, and ex-situ treatment.



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		ESTIMATED EXTENT OF SURFACE SOIL CONTAMINATION PSC 51 RI/FS NAS JACKSONVILLE JACKSONVILLE, FLORIDA	CONTRACT NO. 0253	
							LLK	3/22/02			APPROVED BY	DATE
							CHECKED BY	DATE			APPROVED BY	DATE
							COST/SCHED—AREA					
							SCALE AS NOTED				DRAWING NO. FIGURE 10-2	REV. 0

11.0 SCREENING OF REMEDIAL TECHNOLOGIES AND DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

This section identifies, screens, and evaluates the potential technologies and process options that may be applicable to assemble the remedial alternatives for PSC 51 at NAS Jacksonville. The primary objective of this FS is to develop an appropriate range of remedial technologies and process options that will be used for developing the preliminary remedial alternatives.

The basis for technology identification and screening began in Section 10.0 with a series of discussions that included the following:

- Identification of ARARs
- Development of RAOs
- Identification of General Response Actions (GRAs)
- Identification of volumes or areas of media of concern

Technology screening evaluation is performed in this section with the completion of the following analytical steps:

- Identification and screening of remedial technologies and process options
- Evaluation and selection of representative process options

In this section a variety of technologies and process options are identified under each general response action and screened. The selection and process options for initial screening is based on the "Guidance for Conducting Remedial Investigations/Feasibility Studies under CERCLA" (USEPA, 1988). The screening is first conducted at a preliminary level to focus on relevant technologies and process options. Then the screening is conducted at a more detailed level based on certain evaluation criteria. Finally, process options are selected to represent the technologies that have passed the detailed evaluation and screening.

The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary screening are effectiveness, implementability, and cost. The following are descriptions of these evaluation criteria:

- Effectiveness
 - Protection of human health and environment; reduction in toxicity, mobility, or volume; and permanence of solution.
 - Ability of the technology to address the estimated areas or volumes of contaminated medium.
 - Ability of the technology to attain the PRGs required to meet the RAOs.
 - Technical reliability (innovative verses well-proven) with respect to contaminants and site conditions.
- Implementability
 - Overall technical feasibility at the site
 - Administrative feasibility
 - Special long-term maintenance and operation requirements
- Cost (Qualitative)
 - Capital cost
 - Operation and Maintenance (O&M) costs

Technologies and process options will be identified for the remediation of soil and groundwater in the following sections.

11.1 PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens technologies and process options for soil at a preliminary stage based on implementation with respect to site conditions and contaminants of concern. Table 11-1 summarizes the preliminary screening of technologies and process options applicable to soil. It presents the general response actions, identifies the technologies and process options, and provides a brief description of each process option followed by the screening comments.

The following are the soil technologies and process options retained for detailed screening:

General Response Action	Remedial Technology	Process Option
No Action	None	Not Applicable
Limited Action	Institutional Controls	Active controls (warning signs) and passive controls (land use restrictions).
Removal	Bulk excavation	Excavation
In-situ treatment	Physical/Chemical	Chemical Fixation/Solidification
Disposal	Off-Site Landfill	Hazardous/Non-hazardous Landfill

Table 11-1
Preliminary Screening of Technologies and Process Options for Soil

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not applicable	No activities conducted at the site to address contamination.	Required by NCP. Retain for baseline comparison to other technologies.
Limited Action	Institutional Controls	Active Controls: Physical barriers/ Security guards	Fencing markers, warning signs, and monitoring to restrict site access.	Retain to prevent direct exposure to inorganics in soil.
		Passive Controls: Deed or Land Use Restrictions	Administrative action using property deeds or other land use prohibitions to restrict future site activities.	Retain to prevent future residential development.
	Monitoring	Sampling and Analysis	Sampling and Analysis of soil, groundwater, surface water, sediment, etc. to evaluate natural attenuation and migration of contaminants in the environment.	Eliminate. Natural attenuation and/or migration of contaminants from the site is unlikely due to the characteristics of inorganics.
Containment	Cover	Soil/Multimedia Cover	Use of semipermeable or impermeable barriers to minimize direct exposure to contaminants.	Eliminate. Institutional controls provides similar protection for human health.
	Erosion control	Rip-rap cover/vegetation	Use of gravel/cobbles or dense plant growth to minimize migration of waste/contaminated soils.	Eliminate because of flat terrain.
Removal	Bulk excavation	Excavation	Means of removal of wastes/contaminated soils.	Retain for removal of contaminated materials.

Table 11-1 (Continued)
Preliminary Screening of Technologies and Process Options for Soil

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-situ Treatment	Thermal	Vitrification/ Radio frequency Heating	Use of high-temperature melting to fuse inorganic contaminants into a glass matrix within vadose zone or the use of moderate temperature heating to volatilize contaminants and remove them from the vadose zone.	Eliminate because of implementability concerns due to shallow groundwater table elevation.
	Physical/ Chemical	Soil Flushing	Use of water/solvents to remove contaminants from the vadose zone by flushing and collecting the contaminated wastewater in the saturated zone followed by above ground pump/treat.	Eliminate. Relative ineffectiveness for soil contaminated with inorganics.
		Dynamic Underground Stripping	Steam injection at the periphery of the contaminated area resulting in the vaporization of volatile compounds bound to soil and the movement of contaminants to a centrally located extraction well.	Eliminate. Not applicable for inorganic contaminants.
		Chemical Fixation/Solidification	Mixing of pozzolanic agents in the vadose zone to chemically fix contaminants and solidify the matrix.	Retain. Treatment effective for inorganics at PSC 51.

Table 11-1 (Continued)
Preliminary Screening of Technologies and Process Options for Soil

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment	Physical/Chemical	Soil Washing/Solvent Extraction	Use of solubilization and chemical (oxidation/reduction/neutralization) processes to remove contaminants from the solid phase and convert them into more concentrated forms or less toxic forms in liquid phase.	Retain. Effective for treating inorganic contaminants.
		Chemical Fixation/Solidification	Mixing of pozzolanic agents to chemically fix contaminants and solidify the matrix.	Eliminate. Produces excess volume of contaminants to be disposed.
	Biological	Onsite Landfarming	Tilling of contaminated soils and wastes in layers of surface soil to aerate and biodegrade organic contaminants.	Eliminate. Technology applies to organic compounds.
		Bioslurry Reactor/Biopile	Treatment of soils in a bioslurry reactor or biopile under controlled conditions using natural or cultured microorganisms to biodegrade organic contaminants.	Eliminate. This technology is effective for treatment of organic contaminants.
	Thermal	Off-site Incineration	Use of high temperatures to pyrolyze or oxidize organic contaminants into less toxic gases.	Eliminate. This technology is effective for treatment of organic contaminants.
		Off-Site Low Temperature Thermal Desorption	Use of low to moderate temperatures to volatilize contaminants and remove them from the solid phase into the gaseous phase.	Eliminate. This technology is effective for treatment of organic contaminants.

Table 11-1 (Continued)
Preliminary Screening of Technologies and Process Options for Soil

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Disposal	Landfill (onsite/off-site)	Hazardous/nonhazardous waste landfilling	Disposal of excavated wastes and treatment residuals in a permitted TSDF.	Retain offsite landfilling. Eliminate onsite landfilling because of unavailability of appropriate land.
		Consolidation	Excavation and temporary deposition in one location to minimize space and closure requirements.	Eliminate. Soil contamination only at one location.

11.2 DETAILED SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS

11.2.1 No Action

No Action consists of maintaining status quo at the site. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternative and effectiveness in mitigating risks posed by site contaminants. Since no remedial actions are taken under this alternative, there are no costs associated with “walking away from” the site. There is also no reduction in risk through exposure control or treatment. No action would not be effective in evaluating contaminant mobility and potential migration off-site since no monitoring would be performed.

Effectiveness

No action would not be effective in meeting RAOs. No action would not be effective in evaluating either potential contaminant reduction through NA or potential contaminant migration off site since no monitoring would be performed.

Implementability

There would be no implementability concerns since no action would be implemented.

Cost

There would be no costs associated with No Action.

Conclusion

No action is retained because of NCP requirements although it would not be effective.

11.2.2 Limited Action

11.2.2.1 Institutional Controls

Institutional controls would consist of preparing and implementing a Land Use Control Implementation Plan (LUCIP) for PSC 51. The station currently has an active land use control program under a memorandum of agreement with the regulators and this site would be incorporated into that.

Effectiveness

Prohibiting future non-industrial development of the site would effectively prevent the occurrence of unacceptable risks from direct exposure of human receptors with contaminated soil.

Implementability

Institutional controls would be readily implementable.

Cost

Cost of institutional controls would be low.

Conclusion

Institutional controls are retained in combination with other process options for the development of remedial alternatives.

11.2.2.2 Active Controls

Active controls include physical barriers such as fencing, markers, warning signs, and site monitoring to restrict site access. Physical barriers would be constructed to prevent potential exposure to contaminated soil.

Effectiveness

Active controls would prevent the occurrence of unacceptable risks from direct exposure of humans to contaminated soil.

Implementability

Active controls would be readily implementable, warning signs are easily constructed and NAS Jacksonville is a secure Naval Facility, which is monitored by Naval Police.

Cost

Capital costs would be low.

Conclusion

Active controls are retained in combination with other process options for the development of remedial alternatives.

11.2.3 Removal

The only technology considered under this GRA is excavation. Excavation can be performed by a variety of equipment, such as front-end loaders, backhoes, grade-alls, etc. The type of equipment selected must take into consideration several factors, such as type of material to be removed, the load-bearing capacity of the ground surrounding the removal area, the depth and areal extent of removal, the required rate of removal, and the elevation of the groundwater table. The logistics of excavation must take into account the available space for operating the equipment, loading/unloading to transport the removed material, location of the site, etc. Once excavation is completed, the location is filled and graded with clean fill material or treated soils.

Effectiveness

Excavation is a well-proven and effective method of removing contaminated material from a site. Fill material and contaminated sandy/silty soils, such as those at PSC 51, would be amenable to excavation.

Implementability

Excavation of contaminated soil at PSC 51 would be implementable. Excavation equipment is readily available from multiple vendors. This technology is well proven and established in the construction/remediation industry.

Costs

Costs of excavation at PSC 51 would be moderate.

Conclusion

Excavation is retained for the development of remedial alternatives.

11.2.4 In-situ Treatment

11.2.4.1 Chemical Fixation/Solidification (Soil Stabilization)

Chemical fixation/solidification is the mixing of agents in the vadose zone to chemically fix contaminants and solidify the matrix. The technology works well for inorganic contaminants found at PSC 51.

Effectiveness

Soil stabilization is a proven technique commonly used to solidify contaminants in-situ and remove the contaminants as a risk in the environment. This technology would likely be quite effective for the fixation of the inorganic contaminants in the PSC 51 soil, such as arsenic and lead. A treatability study would be required to determine the most effective chemical additive that would be used as the solidification agent. However, at PSC 51, metal concentrations in soil are low enough that the main risk is associated with direct exposure to contaminated soil, rather than with the potential of contaminant migration. Stabilization would not, of itself, reduce risk from direct exposure and, therefore, an additional technology, such as capping, would also be needed.

Implementability

Soil stabilization is implementable, although a treatability study would be required prior to remediation. Additionally, large amounts of the solidification agent would have to be delivered to the site.

Costs

Costs of soil stabilization are low to moderate, depending on the size of the area to be treated, and the soil-stabilizing agent that would be used.

Conclusions

Soil stabilization is eliminated because of effectiveness concerns.

11.2.5 Ex-situ Treatment

11.2.5.1 Soil Washing-Chemical Extraction

Soil washing uses physical processes such as high-pressure water, screening, attrition scrubbing, froth flotation, electromagnetic separation, mechanical separation, hydrogravimetric separation, and multigravity separation. Such physical separation processes achieve waste minimization through volume

reduction processes by separating out a size fraction of the soil containing little or no contamination from the more highly contaminated, finer-grained material.

Chemical extraction is based on the use of water or other solvents to extract or desorb the contaminants from the soil and dissolve them into the liquid phase. Often, chemical extraction requires a preliminary treatment using physical separation to reduce the volume of material to be treated.

Effectiveness

The effectiveness of soil washing is highly contaminant- and site-specific. A thorough physical and chemical characterization of the contaminant and site hydrogeological conditions is required. Treatability testing would also be essential to determine the most suitable solvent and efficient means of separating the contaminants from the clean soil. Based upon current knowledge of site conditions, there are significant uncertainties regarding the effectiveness of this technology.

Implementability

Soil washing/chemical extraction could be implemented at PSC 51. However, a full-scale soil washing/chemical extraction system would be very complex, consisting of physical separation operations and chemical extraction processes. Chemical extraction would require treatability studies to determine its effectiveness.

Costs

Capital and O&M costs for soil washing/chemical extraction would be moderate to high. Additional costs for disposal of residues could also be moderate to high.

Conclusion

Soil washing/chemical extraction is eliminated from further consideration because of significant effectiveness and implementability concerns.

11.2.5.2 Disposal

Off-site landfilling consists of transporting the excavated soil for burial in an off-site facility. Non-hazardous waste may be disposed of in an RCRA Subtitle D or solid waste landfill. RCRA-hazardous waste must be disposed of in an RCRA Subtitle C or hazardous waste, landfill. It is anticipated that the excavated soil would be classified as RCRA non-hazardous.

Effectiveness

Off-site landfilling does not permanently or irreversibly reduce contaminant concentrations. However, although CERCLA preference for treatment relegates landfilling to a less preferable option, this technology can be an effective disposal option for contaminated soil. Off-site landfills are only permitted to operate if they meet certain requirements of design and operation governing foundation, liner, leak detection, leachate collection and treatment, daily cover, post-closure inspections and monitoring, etc., which ensure the effectiveness of these facilities. The requirements of a RCRA Subtitle C hazardous waste landfill are typically more stringent than those of a RCRA Subtitle D solid waste landfill.

Implementability

Off-site landfilling would be easy to implement. Facilities and services are available. Disposal at RCRA Subtitle D solid waste landfill may require certain pre-treatment, mainly the removal of free liquids, but since soil would only be excavated to one foot bls, this requirement should be easy to meet. In addition, a waste profile would have to be prepared, including indication of contaminants concentrations and their leachability.

Cost

Cost of off-site landfilling would be moderate.

Conclusion

Off-site landfilling is retained in combination with other process options for the development of remedial alternatives.

11.3 SELECTION OF REPRESENTATIVE PROCESS OPTIONS FOR SOIL

The following technologies and process options are retained for the development of soil remedial alternatives:

- No Action
- Institutional Controls/Active Controls
- Excavation
- Off-Site landfilling

11.4 PRELIMINARY SCREENING OF SURFACE WATER TECHNOLOGIES AND PROCESS OPTIONS

The groundwater flow conditions at PSC 51 indicate that groundwater at the site discharges to the unnamed creek. At the present time, surface water COPCs do not present a risk to human health and the environment and do not exceed ARARs. However, because the potential exists for COPCs to discharge to unnamed creek and a theoretical risk may occur in the future, an RAO was developed for surface water. Since, current surface water conditions do not pose a risk to human health and the environment a preliminary screening of surface water technologies was not performed. At this time, the only appropriate and necessary general response action for surface water is monitoring. Therefore, the surface water monitoring at PSC 51 will be incorporated into the groundwater remedial alternative. If in the future COPCs exceed the established PRGs during the long-term monitoring at PSC 51, the NAS Jacksonville Partnering Team should determine an appropriate remedial action for surface water.

11.5 PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens technologies and process options for groundwater at a preliminary stage based on implementation with respect to site conditions and contaminants of concern. Table 11-2 summarizes the preliminary screening of technologies and process options, and provides a brief description of each process option followed by the screening comments.

The following are the groundwater technologies and process options remaining for detailed screening:

General Response Action	Technology	Process Options
No Action	None	Not Applicable
Limited Action	Monitoring	Sampling and Analysis
	Institutional Controls	Passive Restrictions: Deed and Land Use Restrictions
	NA	Naturally-Occurring Biodegradation and Dilution
Removal	Groundwater Extraction	Extraction Wells

Table 11-2
Preliminary Screening of Technologies and Process Options for Groundwater

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida
 Page 1 of 5

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not Applicable	No activities at site to address contamination.	Required by NCP. Retain for baseline comparison to other technologies.
Limited Action	Monitoring	Sampling and Analysis	Periodic sampling and analysis of groundwater and other media to track the spread of contamination.	Retain to assess natural attenuation and/or migration of contaminants from site and evaluate remedial actions.
	Institutional Controls	Passive Controls: Institutional Controls	Institutional controls to prevent use of groundwater at the site for human consumption.	Retain
	Institutional Controls	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, and warning signs to restrict site access.	Eliminate. Plume is located in remote and controlled access area.
	Natural Attenuation	Naturally-Occurring Biodegradation and Dilution	Monitoring the groundwater to assess the contaminant dilution or degradation.	Retain
Containment	Vertical Barriers	Slurry Wall	Low-permeability wall formed in a perimeter trench to restrict horizontal migration of groundwater.	Eliminate. Barrier must be anchored to an impervious layer. At PSC 51 the barrier would need to be anchored to an excessive depth of greater than 50 ft.
		Grout Curtain	Pressure injection of grout to form a low-permeability perimeter wall to restrict horizontal migration of groundwater.	Eliminate. Barrier must be anchored to an impervious layer. At PSC 51 the barrier would need to be anchored to an excessive depth of greater than 50 ft.
		Sheet Piling	Metal sheet piling driven into ground to restrict horizontal migration of groundwater.	Eliminate. Barrier must be anchored to an impervious layer. At PSC 51 the barrier would need to be anchored to an excessive depth of greater than 50 ft.

Table 11-2 (Continued)
Preliminary Screening of Technologies and Process Options for Groundwater

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida
 Page 2 of 5

General Response Action	Technology	Process Options	Description	Screening Comment
Containment (Continued)	Vertical Barriers (Continued)	Hydraulic Barrier	Use of extraction wells and/or collection trenches to restrict horizontal migration of groundwater.	Eliminate. Would involve reinjection for which no acceptable sites are available.
	Horizontal Barriers	Physical Barrier	Injection of bottom sealing slurry beneath source to minimize vertical migration of groundwater.	Eliminate Process only contains plume and will not reduce contaminant concentrations.
Removal	Groundwater Extraction	Extraction Wells	Series of conventional pumping wells used to remove contaminated groundwater.	Retain to remove contaminated groundwater.
		Collection Trench	A permeable trench used to intercept and collect groundwater.	Eliminate due to low concentrations and large capture zone at site extraction wells are more cost effective.
In-situ Treatment	Biological	Aerobic	Enhancement of biodegradation of organics in an aerobic environment by addition of nutrients and oxygen release compounds.	Retain.
		Anaerobic	Enhancement of biodegradation of organics in an anaerobic environment by addition of nutrients and hydrogen release compounds.	Eliminate. Based on NA results and vendor information an oxygen releasing compound has been recommended for enhanced biological treatment.

Table 11-2 (Continued)
Preliminary Screening of Technologies and Process Options for Groundwater

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida
 Page 3 of 5

General Response Action	Technology	Process Options	Description	Screening Comment
In-situ Treatment (Continued)	Physical/ Chemical	Air Sparging/ Vapor Extraction	Volatilization and enhancement of biodegradation of organics by supply of air and extraction of organic compounds.	Retain for treatment of volatile organics.
		Permeable Reactive Barrier	Use of a permeable barrier which allows the passage of groundwater and reacts with contaminants.	Retain
		Dynamic Underground Stripping	Steam injection at the periphery of the contaminated area resulting in the vaporization of volatile compounds bound to soil and the movement of contaminants to a centrally located extraction well.	Eliminate. Not applicable to low concentrations of contaminants.
		Chemical Oxidation	Chemical destruction of organic contaminants through oxidation using a solution of ferrous iron and dilute hydrogen peroxide, or similar process.	Retain
Ex-situ Treatment	Physical	Filtration	Separation of suspended solids from water via entrapment in a bed of granular media or membrane.	Retain as a pretreatment step prior to certain organic removal processes.
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials from water.	Eliminate. Mostly applicable for the treatment of dissolved inorganic compounds.
		Air Stripping	Contact of water with air to remove volatile organics.	Retain for treatment of volatile organics.
		Activated Carbon Adsorption	Separation of dissolved contaminants from water via adsorption onto activated carbon.	Retain for treatment of organics.

Table 11-2 (Continued)
Preliminary Screening of Technologies and Process Options for Groundwater

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida
 Page 4 of 5

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment (Continued)	Physical (Continued)	Solvent Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the contaminants of concern.	Eliminate. Not applicable to low concentrations of contaminants.
		Enhanced Oxidation	Use of oxidizers such as air, ozone, peroxide, chlorine, or permanganate to chemically increase the oxidation state of organic and inorganic compounds.	Retain process for treatment of organic contaminants.
		Distillation	Vaporization of a liquid following by condensation of the vapors to concentrate various constituents.	Eliminate. Not applicable to low concentrations of contaminants.
		Sedimentation	Separation of solids from water via gravity settling.	Retain as a pretreatment step prior to certain organic removal processes.
	Chemical	Ion Exchange	Process in which ions, held by electrostatic forces to charged functional groups on the resin surface, are exchanged for ions of similar charge in a water stream.	Eliminate. Mostly applicable for the treatment of dissolved inorganic compounds.
		Reduction	Use of reducers such as sulfur dioxide, sulfite compounds, or ferrous iron compounds to decrease the oxidation state of organic and inorganic compounds.	Eliminate reduction because it is not applicable to contaminants of concern.
		Chemical Precipitation	Use of reagents to convert soluble constituents into insoluble constituents.	Eliminate due to the low concentrations of dissolved solids.

Table 11-2 (Continued)
Preliminary Screening of Technologies and Process Options for Groundwater

Remedial Investigation/Feasibility Study for PSC 51
 Naval Air Station Jacksonville
 Jacksonville, Florida
 Page 5 of 5

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment (Continued)	Chemical (Continued)	Coagulation/Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Retain as a pretreatment step prior to certain organic removal processes.
		Neutralization/pH Adjustment	Use of acids or bases to counteract excess pHs.	Retain as a possible pretreatment step or final step prior to discharge.
	Biological	Aerobic	Natural degradation of organic contaminants via microorganisms in an aerobic (oxygen) environment.	Retain for treatment of organic compounds.
		Anaerobic	Natural degradation of organic contaminants via microorganisms in an anaerobic (oxygen-deficient) environment.	Retain for treatment of organic compounds.
Discharge/Disposal	Surface Discharge	Direct Discharge (NPDES)	Discharge of treated water.	Retain for discharge of treated groundwater.
		Indirect Discharge (FOTW)	Discharge of collected/treated water to NAS Jacksonville FOTW.	Retain for discharge of treated groundwater.
		Off-Site Treatment Facility	Treatment and disposal of water at an offsite treatment works.	Eliminate. Impractical due to large volume of treated groundwater.
	Subsurface Discharge	Reinjection	Use of injection wells, spray irrigation, or infiltration to discharge collected/treated groundwater underground.	Eliminate- would involve reinjection for which no acceptable sites are available.

General Response Action	Technology	Process Options
In-situ Treatment	Biological	Aerobic biological treatment with addition of oxygen release compounds
	Physical/Chemical	Air Sparging/Vapor Extraction
		Permeable Reactive Barrier
Ex-situ Treatment	Physical/Chemical	Chemical Oxidation
		Air Stripping
		Granular Activated Carbon Adsorption
		Enhanced Oxidation
		Coagulation/ Flocculation
		Sedimentation
		Filtration
	Biological	Neutralization/pH Adjustment
		Aerobic
Discharge/Disposal	On-site Surface Discharge	Anaerobic
		Direct Discharge [National Pollutant Discharge Elimination System (NPDES)]
		Indirect Discharge (FOTW)

11.6 DETAILED SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

11.6.1 No Action

No action consists of maintaining status quo at the site. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternatives and their effectiveness in mitigating risks posed by site contaminants. Since no remedial actions are taken under this alternative, there are no costs associated with “walking away from” the site. Neither is there a reduction in risk through exposure control or treatment.

Effectiveness

No Action would not be effective in meeting the RAOs for the site. No Action would not be effective in evaluating either potential contaminant reduction through NA or potential contaminant migration off-site since no monitoring would be performed.

Implementability

There would be no implementability concerns since no action would be implemented.

Cost

There would be no costs associated with No Action.

Conclusion

No Action is retained for comparison to other options.

11.6.2 Limited Action

11.6.2.1 Institutional Controls

Institutional controls would consist of limiting access to groundwater by restricting future land use. A LUCIP would be prepared and implemented, including deed restrictions to prevent the land from being used in the future as a residential area and to restrict the use of the surficial aquifer as a source of drinking water. A formal request would be made to the agency administering the well installation program in Duval County to not issue permits for installation of drinking water wells at the site that would draw water from the surficial aquifer.

Effectiveness

Land and groundwater use restrictions would be effective, depending on the administration of controls. These controls would minimize potential human health risks associated with exposure to contaminated groundwater.

Implementability

Institutional controls would be readily implementable. Resources are readily available for the preparation of deed restrictions.

Cost

Cost of institutional controls would be low.

Conclusion

Institutional controls are retained in combination with other process options for the development of remedial alternatives.

11.6.2.2 Monitoring

Sampling and analysis of groundwater throughout the area of potential groundwater contamination could be used to evaluate migration of contaminants and the potential for contamination of on-site drinking water supply. Monitoring can also be used to monitor potential NA or the progress of active groundwater remediation.

Effectiveness

Monitoring would not of itself reduce the toxicity, mobility, or volume of contaminants in the groundwater but it would allow the evaluation of potential off-site migration of contaminants and the potential reduction in contaminant concentrations through NA. By serving as a warning mechanism, periodic groundwater monitoring would enable households to discontinue use of groundwater if a threat of contamination arose in the area. Monitoring would also be helpful in measuring and evaluating the effectiveness of groundwater remediation technologies.

Implementability

A groundwater monitoring program could be readily implemented, several monitoring wells are already in place at PSC 51.

Cost

Capital and O&M costs would be low.

Conclusion

Monitoring is retained in combination with other process options for the development of remedial alternatives.

11.6.2.3 Natural Attenuation

NA is defined by the USEPA as naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume or concentration of contamination through those media (USEPA, 1998a).

NA works through nondestructive mechanisms such as dispersion, adsorption, dilution, volatilization, and/or chemical and biological stabilization of contaminants and destruction mechanisms such as biodegradation. NA is recognized as a legitimate and responsible solution for contaminated aquifers and has been shown to be a viable and cost-effective remedial approach.

NA is applicable to PSC 51 based on the contaminants of concern and their ability to biodegrade. NA parameter measurements were performed at PSC 51 during the remedial investigation and the applicability of NA is addressed in the RI portion of this document.

Effectiveness

The results of NA monitoring conducted at PSC 51 during the RI indicated evidence of biodegradation. However, human risks due to ingestion of groundwater from the surficial aquifer would not be addressed via treatment and would remain until concentrations are reduced by natural processes. Groundwater monitoring would provide a means of evaluating the concentrations in groundwater and assessing the degradation rate of contaminants. Monitoring of indicator parameters within the aquifer would help to evaluate the effectiveness of NA in reducing contaminant concentrations.

Implementability

NA would be easy to implement. Monitoring of groundwater and biodegradation, groundwater use restrictions, and periodic site reviews could readily be performed and the necessary resources are available.

Costs

Capital and O&M costs for NA would be low.

Conclusion

NA is retained in combination with other process options for the development of remedial alternatives.

11.6.3 Removal

Groundwater extraction uses a pumping system, composed of a series of wells that are used to capture contaminated groundwater for treatment. The wells used in the capture system are designed and located to provide optimum efficiency in capturing contaminated groundwater while minimizing the collection of uncontaminated groundwater. The feasibility and means of groundwater extraction depend on the hydrogeologic conditions at a site and the depth to contamination. According to the USGS, the surficial aquifer will yield an estimated 5 gallons per minute (gpm) at PSC 51 (Davis 1996). Since a pump test was not conducted at PSC 51 and based on the estimate provided by USGS, it is anticipated that groundwater extraction would be a viable technology.

When an extraction well is used, a cone of depression is created around the well as groundwater is pumped. This influences the local hydrology and causes groundwater to flow toward the well, thereby flushing contaminants from the aquifer. For the purpose of this FS, vertically drilled wells will be considered.

Effectiveness

Groundwater extraction is a well-established and well-proven technology for the removal of contaminated groundwater. While the initial effectiveness of this technology is high, it has often been shown to decrease over time due to contaminant dispersion. The effectiveness of an extraction well system depends largely on the extent of contamination and site-specific geology and hydrology. The use of wells to extract groundwater should reduce contaminant concentration and may attain PRGs over the long term. This technology is reliable and minimal effects on human health and the environment would be expected during implementation.

Implementability

Groundwater extraction through a pumping well system could be readily implementable at PSC 51. This technology uses readily available equipment and techniques and has been widely used in similar situations. Implementation of this technology would require long term operation and maintenance. Local and state permits will be required for installation of the extraction wells.

Costs

Capital and O&M costs for groundwater extraction would be moderate, depending on the extent of the contaminant plume to be remediated.

Conclusion

A pumping well system is retained in combination with other process options for the development of remedial alternatives.

11.6.4 In-situ Treatment

11.6.4.1 In-situ Aerobic/Anaerobic Biological Treatment (Enhanced Biodegradation)

Enhanced biodegradation of groundwater is the process of stimulating natural bacterial biodegradation of organic contaminants. This is accomplished by introducing nutrients to stimulate bacterial growth and speed up biodegradation of organic compounds through DPT or monitoring wells. Biodegradation can be applied using aerobic (oxygen-rich) conditions or anaerobic (oxygen-poor) conditions.

1,1-DCE, vinyl chloride, benzene, ethylbenzene, toluene, xylenes, and naphthalene have been shown to biodegrade under aerobic conditions. Benzene and the other non-chlorinated COPCs are resistant to degradation under anaerobic conditions. The COPCs TCE and 1,2-DCE have been shown to biodegrade under anaerobic conditions. Less chlorinated compounds such as DCE can be degraded either under anaerobic conditions or under aerobic conditions (USEPA, 1998a). Generally, anaerobic degradation of highly chlorinated VOCs produces less chlorinated VOCs. Conversely, the aerobic degradation process produces a variety of complex, oxygenated intermediates, ultimately resulting in the formation of carbon dioxide and water. Aerobic biological treatment with an oxygen releasing compound is the preliminary selected option for PSC 51.

Effectiveness

Enhanced biodegradation is well proven and would be effective for the removal of benzene from groundwater. However, the effectiveness of enhanced biodegradation with respect to chlorinated VOCs, while increasingly documented, is not yet as well established. A treatability study would be needed in order to fully evaluate the process.

Implementability

Enhanced biodegradation could be implemented. The DPT application of oxygen releasing compounds would be relatively unobtrusive. Several qualified contractors would be available for the implementation of this technology.

Cost

Capital and O&M costs for enhanced biodegradation would be low to moderate, depending on the extent of the area treated.

Conclusion

Enhanced biodegradation is retained in combination with other process options for the development of remedial alternatives.

11.6.4.2 Air Sparging (AS)

AS is generally used to remove VOCs from groundwater without extracting the water. AS is the most common aeration technology used at VOC-contaminated groundwater sites. Air is injected into the saturated zone to create turbulence and volatilize organic compounds. As air moves up through the aquifer, contaminants partition into the gas phase and depending on concentrations, are allowed to disperse or are then extracted as organic vapors from the vadose zone. Injected air can also stimulate microbial degradation of contaminants if the required microbes thrive in aerobic conditions (Johnson, Johnson, McWhorter, Hincbee, Goodman, 1993).

AS is typically used in combination with vapor extraction (VE) to control off-gas generated by organic compound volatilization. VE uses negative pressure to collect extracted vapors. Vapor extraction wells or trenches are installed above the water table in a configuration to capture vapors generated from AS. The are sparging system at PSC 51 would most likely not require offgas treatment because of relatively low concentrations of VOCs in groundwater.

Effectiveness

AS would be an effective technology to remove VOCs from groundwater. However, there are certain limitations associated with AS that should be considered. One of these is that air flow through the saturated zone may not be uniform due to non-homogenous soil conditions.

Implementability

AS would be an implementable technology for removal of VOCs from groundwater at PSC 51.

Cost

Capital and O&M costs for AS would be low to moderate, depending on the required treatment duration time and the extent of the area treated.

Conclusion

AS is retained in combination with other process options for the development of remedial alternatives.

11.6.4.3 Permeable Reactive Barriers (PRBs)

PRBs are the emplacement of reactive materials in the subsurface designed to intercept a contaminant plume, provide a flow path through the reactive media, and transform the contaminants into environmentally acceptable forms to attain remediation concentration goals downgradient of the barrier.

PRBs have been used to treat a wide-range of groundwater contaminants, including chlorinated and non-chlorinated VOCs, and inorganic compounds such as hexavalent chromium. Iron metal is, by far the most common reactive medium used in PRBs for the treatment of VOCs. Other materials, such as amended zeolites and bentonites and granular activated carbon (GAC) have been successfully used for the removal of non-chlorinated VOCs, such as benzene.

PRBs are generally built in two basic configurations: funnel-and-gate and continuous. The funnel-and-gate PRB uses impermeable walls (sheet piling, slurry walls, etc.) as a “funnel” to direct the contaminant plume into a “gate” containing the reactive media, whereas the continuous PRB completely intercepts the plume flow path with reactive media.

Effectiveness

The use of PRBs would be effective for the in-situ treatment of groundwater at PSC 51, although the treatment would be over a long time frame as the contaminant plume passes through the PRB. It is expected that the concentrations of the COPCs would eventually be reduced down to their respective cleanup goals.

Implementability

PRBs could easily be installed at PSC 51 to a depth to 20 ft bls since this could be accomplished with conventional equipment. However, the shallow groundwater table may cause complications during installation.

Once installed the O&M requirements of PRBs would be minimal and would essentially be limited to the monitoring of groundwater quality to verify performance.

Cost

Capital cost of the PRBs would be moderate. O&M costs would be low.

Conclusion

PRBs are eliminated due to inferior effectiveness as compared to other in-situ treatment technologies such as in-situ biological treatment, chemical oxidation, and AS.

11.6.4.4 In-situ Chemical Oxidation

In-situ chemical oxidation requires the injection of proprietary liquid chemical formulations into the contaminated portion of the aquifer. Two reactive compounds commonly used for in-situ oxidation of organic contaminants have been identified:

- Fenton's reagent
- Potassium permanganate

In Fenton's Reaction, hydrogen peroxide reacts with ferrous iron to produce the hydroxyl radical, a powerful oxidizer. The hydroxyl radical progressively reacts with organic compounds to produce carbon dioxide and water. When the oxidized organic compound is chlorinated, chloride ions are also released. If potassium permanganate is used instead of Fenton's reagent then the potassium permanganate ion rather than hydrogen peroxide, is used as the reagent. When the potassium permanganate oxidizes a chlorinated organic compound, it produces carbon dioxide, manganese dioxide and chloride ions. The reaction may result in a temporary exceedance of the secondary groundwater standards for color, total dissolved solids, manganese, pH, and chloride. Treatability testing is typically required to verify the effectiveness of in-situ chemical oxidation.

Effectiveness

Chemical oxidation would be effective to remove VOCs from groundwater. A treatability study would be needed in order to fully evaluate the process.

Implementability

Chemical oxidation would be implementable. This technology is applicable to the lithology found at PSC 51. This technology would require a bench-scale study in order to assess the compound treatment quantity.

Cost

Cost of chemical oxidation would be moderate to high, depending on the extent of the area treated.

Conclusion

Chemical oxidation is retained in combination with other process options for the development of remedial alternatives.

11.6.5 Ex-situ Treatment

11.6.5.1 Air Stripping

Air stripping and aeration technologies also known as extraction-and-treatment are used to remove VOCs from contaminated water. The VOCs are transferred from liquid to the vapor phase by contacting the water with a continuous supply of clean air. Although many vendor specific air stripping and aeration units exist, they can be grouped into the following categories, based on the mechanism used to maximize the air-water interface:

- packed towers
- diffused aeration
- cascade towers
- tray towers

The counter current packed tower is the most commonly used air stripping configuration. Key factors that influence process performance include air to water ratio, height of packing and type of packing material, operating temperature, surface hydraulic loading, and contact time.

Effectiveness

Air stripping is a well proven and reliable technology that would be effective for removing the VOCs of concern from groundwater at PSC 51. Removal efficiencies greater than 99 percent could theoretically be

achieved at PSC 51. Since air stripping only removes the contaminants from the water and concentrates them in the exhaust gas, this gas is usually treated by a vapor-phase GAC adsorption. At PSC 51 offgas treatment is not likely to be required because of relatively low VOC concentrations in the groundwater to be treated.

Implementability

Air stripping would be readily implementable. There are a significant number of vendors that provide air stripping equipment.

A maintenance problem commonly associated with air stripping is the channeling of flow resulting from clogging in the packing material. Typical causes of clogging include high oils, suspended solids, and iron concentrations, and slightly soluble salts such as calcium carbonate.

Cost

Capital cost for air stripping would be low. O&M costs would be moderate.

Conclusion

Air stripping is retained in combination with other process options for the development of remedial alternatives.

11.6.5.2 Organic Adsorption

Adsorption is a process in which a substance is transferred from water to a solid medium. This technology has demonstrated effectiveness for treatment of VOCs. The molecule that accumulates or adsorbs at the water-solid interface is called the adsorbate, and the solid on which the adsorption occurs is the adsorbent. Common adsorbents in water treatment include activated carbon, ion exchange resins, adsorbent resins, metal oxides, and carbonates. While some of these technologies are used primarily for the treatment of inorganic compounds, GAC and powdered activated carbon are technologies commonly used for the treatment of organic compounds.

Effectiveness

Liquid-and vapor-phase GAC adsorption is a well proven, reliable technology that would be effective for removing most of the VOCs of concern from the groundwater at PSC 51. Removal efficiency exceeding 99 percent is possible depending on the type of organic solute and system operating retention time.

Implementability

GAC adsorption would be readily implementable. There are a sufficient number of qualified vendors that provide GAC adsorption units.

In the case of liquid-phase GAC adsorption, pretreatment would be required to prevent premature carbon fouling if the groundwater to be treated has a suspended solids concentration greater than 50 mg/L, or calcium or magnesium concentrations greater than 500 mg/L. At PSC 51, a filtration pretreatment step is likely to be required as a safeguard to ensure maximum GAC life. Spent GAC containing the concentrated organic contaminants would have to be regenerated, incinerated, or disposed of in a hazardous waste landfill. Special handling of the periodically generated backwash liquids must also be taken into account.

Cost

Capital cost for GAC adsorption would be low while O&M costs would range from low to high, depending on the carbon usage rate, which is a function of influent contaminant concentrations.

Conclusion

GAC adsorption is retained in combination with other process options for the development of remedial alternatives.

11.6.5.3 Enhanced Oxidation

Oxidation involves destroying VOCs in groundwater by changing the oxidation state of target contaminants. Contaminants at PSC 51 primarily consist of VOCs, and oxidation is attractive for use at contaminated sites, as the systems have very low, if any, air emissions.

Ultraviolet light and oxidation (UV/OX) is a process that enhances oxidation by exposing contaminated water to ultraviolet light. UV/OX enhances oxidation of hydrocarbons into carbon dioxide (CO₂) and water. Oxidants typically used with UV/OX include hydrogen peroxide (H₂O₂) and/or Ozone (O₃). Other chemical oxidants may be used alone to treat organic compounds through oxidation.

Effectiveness

Enhanced oxidation with hydrogen peroxide/ozone and UV technology has been proven effective for the destruction of halogenated organic compounds, benzene derivatives, and various aliphatic hydrocarbons. tetrachloroethene and TCE have been reduced from 20 mg/L to less than 5 µg/L. Effectiveness varies greatly depending on the contaminant of concern. For PSC 51 groundwater, benzene and chlorinated alkenes such as TCE, tetrachloroethene, and 1,2-DCE would be readily removed while chlorinated alkanes such as trichloroethane and dichloroethane would be more refractory.

Implementability

Enhanced oxidation with hydrogen peroxide/ozone and UV would be readily implementable. However, only a few vendors currently offer this technology.

Cost

Capital cost of enhanced oxidation with hydrogen peroxide/ozone and UV would be moderate to high. O&M costs vary significantly depending on flow rate, and contaminant type and concentration.

Conclusion

Enhanced oxidation with hydrogen peroxide/ozone and UV is eliminated from further consideration due to the fact that air stripping is more cost effective.

11.6.5.4 Coagulation/Flocculation and Sedimentation

Coagulation/flocculation is a process which consists of adding certain chemical reagents which result in the agglomeration of small suspended solids particles into larger ones, thus increasing significantly the effectiveness of sedimentation.

Sedimentation is a process that removes the suspended solids from a liquid by producing quiescent hydraulic conditions. This allows gravity to settle out the unstable solids from suspension. This technology may be used in conjunction with precipitation. Two slightly different sedimentation options are used including clarification (to typically produce 2 to 8 percent sludge) and thickening (to typically further concentrate clarification sludge to 8 to 15 percent).

Effectiveness

Coagulation/flocculation and sedimentation would not of themselves be effective for the removal of COPCs from groundwater at PSC 51. However, these technologies would be effective for the removal of excessive concentrations of suspended solids that would otherwise undermine the efficiency of COPC removal technologies such as air stripping and GAC adsorption. Based on previous characterization of the groundwater at PSC 51, minimal amounts of suspended solids are likely.

Implementability

Coagulation/flocculation and sedimentation would be readily implementable. Numerous qualified equipment vendors and contractors offer this type of equipment and services.

Cost

Capital and O&M costs for coagulation/flocculation and sedimentation would be moderate.

Conclusion

Coagulation/flocculation and sedimentation are eliminated because other processes can reduce the expected suspended solids at a lower cost for O&M.

11.6.5.5 Filtration

Filtration is a process using a porous medium to remove solid particles from a liquid or gas phase. This technology is generally used as a groundwater pre-treatment to remove suspended solids before other treatment processes and/or for the final cleaning or polishing of treated effluent.

Effectiveness

Filtration would not be expected to be effective of itself for the removal of COPCs from groundwater at PSC 51. However, this technology would be effectively reduce excessive concentrations of solids particles suspended in the groundwater and that might otherwise undermine the efficiency of downstream treatment technologies such as air stripping and liquid-phase GAC adsorption. Filtration would also effectively remove whatever contaminants may be adsorbed on the solid particles suspended in the groundwater. At PSC 51 it is expected that filtration would be necessary for the pretreatment of PSC 51 contaminated groundwater to reduce solids prior to air stripping and liquid-phase GAC adsorption.

Implementability

Filtration would be readily implementable. Filtration systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. Liquid or solid residues resulting from periodic cleaning or replacement of the filter medium would have to be properly disposed.

Cost

Capital and O&M costs for filtration would be low.

Conclusion

Filtration is retained in combination with other process options for the development of remedial alternatives.

11.6.5.6 Neutralization/pH Adjustment

Neutralization/pH adjustment is a process for achieving appropriate pH levels for removal of contaminants. This is generally accomplished by adding acidic compound to balance alkaline solutions or vice-versa.

Effectiveness

Neutralization/pH adjustment is generally effective for the removal of certain contaminants, mostly inorganics, by bringing them out of solution. For PSC 51, neutralization/pH adjustment would not of itself be effective for the removal of COPCs in groundwater. However, this technology would enhance the effectiveness of such pretreatment technologies as coagulation/flocculation and sedimentation and may be required prior to discharge of treated groundwater.

Implementability

Neutralization/pH adjustment would be readily implementable. This technology is widely used and numerous qualified equipment vendors and contractors offer this type of equipment and services.

Cost

Capital and O&M costs for neutralization/pH adjustment would be low.

Conclusion

Neutralization/pH adjustment is eliminated because the pH of the extracted groundwater is anticipated to be acceptable for discharge and pH adjustment would not be required for removing contaminants out of solution. Therefore, it is eliminated from further consideration.

11.6.5.7 Ex-situ Aerobic/Anaerobic Biological Treatment

Biological treatment is a common method of reducing the concentration of organic compounds in wastewater. The same techniques typically applied in wastewater treatment can be applied to groundwater treatment. Aerobic or anaerobic conditions can be applied depending on which method can degrade the COPCs better. Biological treatment methods are categorized as either suspended growth or attached growth.

Ex-situ biological treatment consists of contacting the contaminated groundwater with a concentrated culture of microorganisms under controlled operating conditions, including mixing, presence or absence of oxygen, pH, temperature, and addition of nutrients.

Effectiveness

Ex-situ aerobic biological treatment is a well-proven technology would effectively remove petroleum hydrocarbons from the groundwater at PSC 51. However, the effectiveness of ex-situ anaerobic biological treatment with respect to chlorinated VOCs is not nearly as well established. A treatability study would be needed in order to fully evaluate the process.

Implementability

Ex-situ biological treatment would be implementable. Numerous qualified vendors and contractors offer equipment and services for ex-situ aerobic treatment of non-chlorinated VOCs, such as benzene. However, availability of proven technology and know-how for ex-situ anaerobic biological treatment of chlorinated VOCs is very limited.

Implementation of ex-situ aerobic/anaerobic biological treatment for PSC 51 groundwater would require pre-treatment for suspended solids removal and treatment and disposal of the residues generated by these processes.

Cost

Capital and O&M costs for ex-situ aerobic/anaerobic biological treatment would be low to moderate.

Conclusion

Ex-situ aerobic/anaerobic biological treatment is eliminated from further consideration because of concerns regarding its effectiveness for the removal of chlorinated VOCs and because of the relative complexity introduced by the requirement for treatment and disposal of treatment residues.

11.6.6 Disposal

If a remedial alternative for groundwater includes extraction, an effluent method of discharge dictates the degree of treatment required. The discharge options for groundwater are discussed in the following paragraphs.

11.6.6.1 Direct Discharge

Groundwater extracted and treated may be discharged to the St. Johns River (i.e., surface water) via direct pipeline to the nearby unnamed creek which ultimately discharges to the St. Johns River. Anticipated treatment levels for discharge to surface water would have to meet the treatment requirements for discharge to surface water as specified by State and Federal regulations.

Actual treatment levels may be modified by FDEP during remedial design. A NPDES permit would not be required since such permits are not typically required for discharges from CERCLA sites. However, the treated groundwater would have to meet the substantive requirements of an NPDES permit. Technology-based and water-quality based treatment levels would be considered.

Effectiveness

Direct discharge of groundwater to the unnamed creek would be an effective means of disposal for groundwater at PSC 51. However, the groundwater would have to undergo adequate treatment verification by monitoring for this option to be environmentally acceptable.

Implementability

Direct discharge of groundwater to the unnamed creek would be implementable. Prior to discharge, groundwater would have to be treated to comply with Florida Water Quality Standards. Ongoing

monitoring of discharged water would be required to ensure that the unnamed creek and other areas downstream are not adversely effected. These requirements would be implementable and the resources necessary to satisfy them are available.

Cost

Capital costs of direct discharge would be low. O&M costs would be low to moderate depending on the duration of this alternative.

Conclusion

Direct discharge is eliminated from further consideration due to implementability restrictions.

11.6.6.2 Indirect Discharge

The FOTW at NAS Jacksonville is an activated sludge treatment plant that includes facilities for collection, primary treatment, secondary treatment, tertiary filtration, and disinfection of the final effluent. The FOTW is capable of providing treatment for extracted groundwater provided that constituents in the groundwater do not exceed levels that can be reduced sufficiently within the FOTW to meet its effluent requirements (HLA, 1999b).

The advantage of discharging water to the FOTW is that existing treatment capacity of the FOTW is used, and due to low levels, only minor pretreatment would be required to reduce constituent concentrations to a level that can be effectively treated by the FOTW to meet their permit-required discharge limits.

Effectiveness

Indirect discharge to the FOTW would be an effective means for the disposal of the PSC 51 groundwater. The FOTW would provide the necessary polishing treatment for ultimate discharge to surface water.

Implementability

The NAS Jacksonville FOTW would provide treatment of the organic compounds found in extracted groundwater at PSC 51. It is assumed that a connection to the sanitary sewer could be made at a building located approximately 2000 ft to the east. Additionally, the FOTW at NAS Jacksonville could handle the estimated 6 gpm flow rate of discharged groundwater, and consideration has been made for the proposed discharge of treated groundwater from other extraction and treatment systems of far larger design (HLA 1999b).

Cost

Capital and O&M costs or indirect discharge to the local FOTW would be low.

Conclusion

Indirect discharge is retained for further consideration in combination with other remedial actions.

11.7 SELECTION OF REPRESENTATIVE PROCESS OPTIONS FOR GROUNDWATER

The following technologies and process options are retained for development of groundwater remedial alternatives:

- No Action
- Institutional Controls
- Monitoring
- NA
- Groundwater Extraction
- In-situ Enhanced biodegradation
- In-Situ Chemical Oxidation
- Air Sparging
- Air Stripping
- GAC Adsorption
- Filtration
- Indirect Discharge

11.8 SUMMARY OF RETAINED REMEDIAL TECHNOLOGIES ASSEMBLED INTO REMEDIAL ALTERNATIVES

This section describes the retained remedial technologies and their assemblance into remedial alternatives.

The following technologies and process options are retained and/or combined to form the remedial alternatives for detailed analysis in Section 12.0:

- The No Action Alternative (S-1).
- The Limited Action Alternative (S-2) is a combination of the passive institutional control of land use restrictions, and the active institutional controls of warning signs and monitoring.
- The Excavation and Disposal Alternative (S-3) is a combination of the removal alternative of soil excavation and the disposal alternative of disposal of soil at an approved landfill.

The following retained groundwater alternatives are combined to form the remedial alternatives for detailed analysis in Section 12.0:

- The No Action Alternative (GW-1).
- The NA Alternative (GW-2) is a combination of the passive institutional control of land use restrictions, groundwater monitoring, and monitored NA.
- The In-Situ Enhanced Biodegradation Alternative (GW-3) is a combination of the passive institutional control of land use restrictions, groundwater monitoring, and in-situ enhanced biodegradation.
- The In-Situ Chemical Oxidation Alternative (GW-4) is a combination of the passive institutional control of land use restrictions, groundwater monitoring, and in-situ chemical oxidation.
- The Extraction-and-Treatment Alternative (GW-5) is a combination of the passive institutional control of land use restrictions, groundwater monitoring, groundwater extraction via extraction wells, filtration of extracted water, air stripping for treatment of extracted water, GAC adsorption for polishing of treated water prior to discharge, and indirect discharge of groundwater to the NAS Jacksonville FOTW.
- The Air Stripping Alternative (GW-6) is a combination of the passive institutional control of land use restrictions, groundwater monitoring, and AS.

12.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the detailed analyses of remedial alternatives that address contaminated groundwater and surface soil at NAS Jacksonville. A detailed analysis is performed to provide decision-makers with sufficient information to select the appropriate remedial alternatives for each contaminated medium at PSC 51. The detailed analyses have been conducted in accordance with CERCLA Section 121, the NCP, and USEPA RI/FS guidance.

The detailed evaluation of each remedial alternative includes the following:

- A detailed description of the alternative, emphasizing the application of the technology or actions proposed for each alternative.
- A detailed analysis of the alternative against several criteria.

The remedial alternatives are examined with respect to the requirements stipulated by CERCLA and factors described in the USEPA RI/FS guidance manual (USEPA, 1988). The nine criteria from the RI/FS guidance document are:

- Overall protection of human health and the environment.
- Compliance with ARARs.
- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, and volume through treatment.
- Short-term effectiveness.
- Implementability.
- Economic (i.e. cost).
- State acceptance.
- Community acceptance.

While FDEP and USEPA have participated in the development of this document through the NAS Jacksonville Partnering Team, the State and community acceptance criteria are more appropriately evaluated upon receipt of public comments on the FS and proposed plan (USEPA, 1988). The ROD for PSC 51 will address community acceptance in its responsiveness summary, where responses to comments received during a public comment period on the FS presents the evaluation of the first seven criteria in the alternative evaluation process. Table 12-1 outlines the specific elements considered for these seven criteria.

Table 12-1
Factors for Detailed Analysis of Remedial Alternatives

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Factors	Criteria to Consider
Overall protection of human health and the environment	How risks are eliminated, reduced, or controlled. Short-term or cross media effects.
Compliance with ARARs	Compliance with chemical, location, and action specific ARARs.
Long-term effectiveness and permanence	Magnitude of residual risk, adequacy and reliability of controls.
Reduction of mobility, toxicity, and volume through treatment	Treatment process and remedy Amount of hazardous materials destroyed or treated. Reduction of mobility, toxicity, or volume through treatment. Irreversibility of treatment. Type and quantity of treatment residual.
Short-term effectiveness	Protection of community during remedial action. Protection of workers during remedial action. Environmental effects. Time until RAOs are achieved.
Implementability	Ability to construct technology. Reliability of technology. Ease of undertaking additional remedial action, if necessary. Coordination with other technologies. Administrative requirements.
Cost	Capital cost. O&M cost. Total present worth of alternative.

12.1 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR SURFACE SOIL

This section presents the detailed analysis for the selected remedial alternatives that address contaminated soil at PSC 51:

- No Action
- Limited Action
- Excavation and Disposal

Remedial alternatives were developed in Subsection 11.1.1.1 to address soil contamination at PSC 51. In the detailed analysis of these alternatives, the focus of the evaluation will be on these selected individual alternatives.

In the comparative analysis of alternatives presented in Section 13.0, the focus will be placed on evaluation of alternatives.

12.1.1 Alternative S-1:No Action

This alternative does not involve the implementation of a containment, treatment, or disposal technology for soil at PSC 51. This alternative is described in Subsection 12.1.1.1 and evaluated in Subsection 12.1.1.2.

12.1.1.1 Detailed Description

In accordance with the NCP, the No Action alternative is used as a baseline for comparison against alternatives that incorporate remedial actions. Under this alternative, soil would remain in place, thus allowing natural processes to reduce the concentrations of the inorganic COPCs. No other additional remedial actions (e.g., monitoring) or institutional controls to prevent exposure would be implemented under this alternative.

12.1.1.2 Technical Criteria Assessment

The technical assessment of Alternative S-1 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would not protect human or ecological receptors from coming in contact with contaminated soil at PSC 51. The HHRA identified arsenic as a risk above the FDEP risk threshold and several noncarcinogenic metals as a potential risk for residential exposures. The ERA determined maximum cadmium, chromium, copper, lead, nickel, and zinc concentrations are elevated relative to probable effects levels and could possibly be affecting plants

and soil organisms. However, from an ERA perspective the site does not appear to warrant further action. This alternative would not provide measures to control exposure to soil to reduce the risk to human receptors.

Compliance with ARARs. Because there are no Federal or State promulgated regulatory cleanup values for soil, there are no soil-based ARARs identified for this site. However, concentrations in soil would not meet State guidance criteria.

Long-Term Effectiveness and Permanence. Under this alternative, no remedial measures would be implemented. Risks to human health receptors resulting from exposure to soil at PSC 51 are above FDEP acceptable criteria. Naturally occurring processes, such as biological activity, are not expected to reduce contaminant concentrations of arsenic in soil. Human risks due to direct contact with soil at the site would not be addressed and would remain over a period that could be several decades.

Reduction in Toxicity, Mobility, and Volume of Wastes. No Action provides no active treatment for reduction of the concentrations of inorganics in soil at PSC 51. Naturally occurring processes would be relied upon to reduce the concentrations of inorganic chemicals in soil through biodegradation or transformation. The soil would remain in place, and no barriers would be constructed to prevent mobilization of contaminants.

Short-Term Effectiveness. Because no active remedial measures would be conducted as part of this alternative, there would be no short-term damages in risks to human receptors due to exposure to soil at PSC 51. The RAOs would never be met.

Implementability. This alternative is presently in place at PSC 51. No special implementability concerns have been encountered, and no further implementability concerns are expected if this alternative were chosen.

Costs. There are no costs associated with the No Action alternative.

12.1.2 Alternative S-2:Limited Action

Under the Limited Action alternative, actions would be taken to reduce the risk to human receptors posed by direct contact with soil at PSC 51. A description of this alternative is presented in Subsection 12.1.2.1 and a technical assessment of this alternative is presented in Subsection 12.1.2.2.

12.1.2.1 Detailed Description

Under this alternative, metal contaminated soil would remain in place at PSC 51. Actions would include land use controls and periodic monitoring of the site as part of the LUCIP program at NAS Jacksonville, and warning signs posted at the site, to prevent exposure to contaminated soil. Major components of this alternative include:

- Institutional Controls
- Monitoring
- Warning signs, and
- Five-year site reviews.

Warning Signs. Hazard signs would be posted at regular intervals along the boundary of PSC 51 to warn NAS Jacksonville personnel and workers of the hazards associated with the site. The cost to furnish and install four warning signs is approximately \$500.

Site monitoring. PSC 51 would be incorporated into the current LUCIP at NAS Jacksonville. Under this LUCIP, sites are monitored several times a year to assure that restrictive measures such as signs are maintained. Site sampling would not occur because metal concentrations in soil are not expected to change for several decades.

Institutional controls. Base utility maps, land-use plans, and property deeds for land in the vicinity of the areal extent of surface soil contamination at PSC 51 would be annotated to indicate that direct contact with soil may pose a health risk. The annotation would reference the RI, Baseline RA, FS, Proposed Plan, and ROD. Planning agencies and permitting agencies would be reminded annually of these land-use restrictions. These restrictions would be removed when a 5-year site review indicates, based on the site monitoring program results, that the PSC 51 action levels have been achieved. A 30-year period was assumed for estimating costs.

Five-Year Site Reviews. Because wastes and associated risks are left onsite, the Navy, USEPA, and FDEP must review site conditions and determine whether or not the continued implementation of this alternative is appropriate. Site reviews would occur every five years until the action levels are attained. Reviews would consist of assessing changes in site conditions (e.g., construction, demolition, receptors, migration pathways, and qualitative risks). The appropriateness of this alternative would be compared to other remedial alternatives to confirm that this alternative was still the most appropriate selection for PSC 51.

12.1.2.2 Technical Criteria Assessment

The technical assessment of alternative S-2 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would not prevent but would limit the possibility for humans from coming in contact with contaminated soil at PSC 51. Warning signs, and institutional controls would discourage entry into the contaminated area, protecting human health.

Compliance with ARARs. Although ARARs were not identified for soil, this alternative would comply with guidance criteria identified for this site. PSC 51 is in an industrial designated area of NAS Jacksonville, where FDEP industrial SCTLs are more appropriate than residential SCTLs. As indicated by the statistical analysis in Section 5.0, the few exceedances of industrial SCTLs (lead and arsenic) were statistical outliers. The limited action alternative would limit the potential exposure to metals in surface soil, particularly in an industrial setting.

Long-term Effectiveness and Permanence. Naturally occurring processes are not expected to reduce contaminant concentrations of inorganics in the soil. However, human risks due to direct contact with soil at the site would be reduced, and would remain over a period of several decades.

The administrative actions proposed in this alternative would provide a means of exposure control, but would not provide a permanent remedy for risks posed by the site. Administrative actions are considered reliable controls.

Reduction of Toxicity, Mobility, and Volume through Treatment. Active treatment is not included in this alternative. This alternative would not provide a reduction in contaminant mobility or volume because active remedial actions are not proposed. This alternative would not enhance or increase the rate of natural transformation processes that reduce the toxicity, mobility, or volume of contaminants in soil.

Human health toxicity posed by direct contact with soil at the site would remain over a period of several decades until concentrations are reduced by natural processes.

No treatment residuals would be produced if this alternative were implemented.

Short-Term Effectiveness. The impact to the surrounding community by implementing this alternative would be minimal, and standard personal protective equipment will be required for site workers if this alternative is implemented. This alternative can be implemented relatively quickly, preventing exposure and therefore requiring minimal time to meet the RAO.

Implementability. This alternative involves minor activities for implementation, such as sign installation, implementation of institutional controls and 5-year site reviews. These activities are easily implemented, although administratively burdensome.

Costs. Estimated costs for Alternative S-2 would be as follows:

- Capital Cost: \$5,000
- Present Worth of O&M Cost \$71,000
- Net Present Worth with Contingency \$101,00

The above figures were rounded to the nearest \$1,000 to reflect the preliminary nature of the estimates. A detailed cost breakdown is provided in Appendix M.

12.1.3 Alternative S-3:Excavation and Disposal

Subsection 12.1.3 presents the detailed analysis of the excavation and disposal alternative. A description of this alternative is presented in Subsection 12.1.3.1 and a technical criteria assessment of this alternative is presented in Subsection 12.1.3.2.

12.1.3.1 Detailed Description

Under this alternative, contaminated soil is removed from the site and transported off-site to either a hazardous or nonhazardous waste landfill. The excavation and disposal procedure will be as follows:

- Site clearing and pre-excavation activities.
- Excavation of contaminated soil.
- Testing of excavated soils to determine if they are RCRA hazardous [i.e., if the soils are subject to land disposal restrictions (LDRs)].
- Transportation and disposal of soil to a solid waste landfill.
- Backfilling of excavated area.
- Closeout activities.

Site Clearing and Pre-excavation Activities. Site clearing and preparation would include all activities and construction necessary prior to excavation of contaminated soil at the site. These activities would include:

- Collection of composite soil samples for off-site laboratory analysis to determine if soil at PSC 51 requires treatment prior to land disposal, as required by the LDRs established under the Hazardous and Solid Waste Amendments.

- Collection and documentation of necessary permits prior to the onset of intrusive work at PSC 51.
- Location and staking of underground utilities at PSC 51.
- Construction of a temporary fence encompassing the excavation area to control access and represent the limits of PSC 51 during remedial activities.
- Grubbing (i.e., removal of vegetation).
- Setup of decontamination area and laydown area for equipment.
- Stockpiling of clean fill for backfill of excavated areas.

Four composite soil sample would be collected from the soil to be excavated. The soil samples would be analyzed for TAL metals and TCLP metals (USEPA Method 1311/6000/7000). The mass and leachable concentrations of the target constituents in the representative soil samples will be compared to concentration limits specified by the LDRs to determine if site soil will be placed in a hazardous waste land disposal unit or disposed of in a Subtitle D facility. Evaluation of results from previous samples collected during the RI indicate that the soil may be hazardous and may require disposal in a Subtitle C RCRA regulated facility. This alternative is assumed based on the chromium and mercury results and the general rule of dividing the metals concentration by 20 to determine TCLP concentrations. Therefore, for costing purposes disposal of soil was estimated for a Subtitle C facility. If this alternative is selected it is recommended that excavated soil be segregated to reduce disposal costs.

Although permits are typically waved for remedial activities carried out at CERCLA sites, the intent of any construction and work permits must be attained. All underground utilities at PSC 51 will be located and staked.

A temporary fence (e.g., snow or dune fence) would be installed to enclose the excavation area at PSC 51. This fence should be placed at a minimum radius of 30 ft from the excavated areas. The fence would be rolled back during working hours to provide entry and exit of vehicles and equipment throughout the implementation of this alternative.

Excavation of Contaminated Soil. A backhoe would be used to excavate the contaminated soil to a depth of one foot bls. Analytical results from the RI indicated metal concentrations above Florida soil cleanup criteria for soil samples at the locations indicated on Figure 10-2. To assure removal of metals to FDEP

residential SCTLs, the excavation would include the removal of soil 50 ft out from the soil exceedances at the FFTA. The limits of excavation of contaminated soil are indicated on Figure 10-2. The total area of excavation is a 30,081 ft².

It was estimated that a total of 1,560 tons of soil would be removed from the limits of excavation. Calculations for this estimate are located in Appendix L.

The soil would be placed directly into the trucks for transportation to an appropriately permitted off-site disposal facility. Dewatering of soil would not be required because excavation would not encroach further than 1 ft bls.

To confirm that all contaminated soil has been excavated, twenty-five soil samples would be collected from the bottom and side walls of the excavations and analyzed for TAL metals.

Backfilling of Excavated Areas. The open excavations would be backfilled at the direction of the engineer of record following the review of the confirmatory sampling results. Backfill would be staged at the designated area onsite.

Transport and Off-site Disposal of Soil. Soil would be placed directly into trucks for transport during excavation. Ten mil or heavier plastic sheeting will be placed on the ground to contain inadvertent spills. Once full, trucks would transport contaminated soil to an appropriately permitted off-site landfill for disposal. Transportation and disposal of soil would be ongoing throughout the time span of soil excavation activities at PSC 51.

Closeout Activities. Once excavation and disposal activities at PSC 51 are concluded, closeout activities would occur. These activities would include:

- Removal and cleanup of the decontaminated area temporary fence, clean fill staging area, and equipment.
- Grading and revegetation of PSC 51.

It is assumed that the excavation and disposal of the soil will take approximately two weeks.

12.1.3.2 Technical Criteria Assessment

The technical assessment of alternative S-3 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would be protective of human health by reducing the amount of metals, which could be exposed via ingestion, dermal contact, and inhalation of particulates. Some short-term and cross-media effects are possible with this alternative from potential releases, especially during transportation activities. Monitoring and engineering controls would be implemented during the remedial action to minimize these effects.

Compliance with ARARs. While chemical-specific ARARs are not available for contaminants in soil at PSC 51, it is expected that source removal and disposal activities outlined in the previous subsection would comply with action-and location-specific ARARs. All generated wastes produced during removal activities would be managed according to these ARARs.

Long-Term Effectiveness and Permanence. Because inorganics would not be destroyed or removed through treatment, this alternative would not be considered a permanent remedy. However, removal from the site provides long-term and permanent effectiveness at PSC 51, and off-site disposal at a landfill is reliable at isolating wastes to prevent migration and exposure.

Reduction in Toxicity, Mobility, and Volume through Treatment. This alternative would not reduce the toxicity, mobility, or volume of contaminants through treatment. However, mobility would be reduced by containment. Approximately 1,560 tons of contaminated soil would be excavated and contained. This containment is only effective as long as the off-site landfill is properly maintained.

Short-Term Effectiveness. Dust emissions would be monitored during remediation and protective clothing would be worn by site workers to protect against contaminated soil. Special precautions would be necessary to prevent soil spillage during transport. This alternative is expected to take two weeks to complete.

Implementability. The techniques that would be used for soil excavation are well developed, commonly used, and should not be difficult to implement. Excavation is a reliable technology that would not be expected to result in technical difficulties leading to excessive schedule delays. A confirmatory sampling program in the area to be remediated would be used to confirm that soil exceeding the remedial goals is removed.

Coordination with NAS Jacksonville, USEPA, FDEP, county, and city personnel would be necessary for handling and disposal. Approval from the State and USEPA will be necessary prior to off-site disposal of contaminated soil.

Land disposal reliability reduces migration and exposure. Several permitted facilities for land disposal of contaminated soil are located within an acceptable area of NAS Jacksonville. This alternative would not inhibit additional remedial actions at the site if necessary.

Costs Estimated costs for Alternative S-3 would be as follows:

Capital Cost: \$615,000

A detailed cost breakdown is provided in Appendix M.

12.2 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER

Detailed Analysis of Remedial Alternatives for Groundwater

This section presents the detailed analysis for remedial alternatives that address contaminated groundwater at PSC 51:

- No Action
- NA
- Enhanced Biodegradation
- Chemical Oxidation
- Extraction and Treatment
- AS

Remedial alternatives were developed in Subsection 11.2.2 to address groundwater contamination at PSC 51. In the detailed analysis of these alternatives, the focus of the evaluation will be on the selected individual alternatives.

In the comparative analysis of alternatives presented in Section 13.0, the focus will be placed on evaluation of alternatives.

12.2.1 Alternative GW-1:No Action

Under the No Action alternative, no actions will be taken to address contaminated groundwater. A description of this alternative is presented in Subsection 12.2.1.1, and a technical criteria analysis of this alternative is presented in Subsection 12.2.1.2.

12.2.1.1 Detailed Description

In accordance with the NCP, Alternative GW-1 is used as a baseline for comparison against alternatives that incorporate remedial actions. No restrictions or remedial action will be performed under this alternative.

12.2.1.2 Technical Criteria Assessment

The technical assessment of Alternative GW-1 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would not protect human receptors from exposure to contaminated groundwater. The risk assessment for PSC 51 predicted unacceptable risk to human health associated with contaminants in groundwater for exposure scenarios evaluated (see Section 7.0). The unacceptable risk would not be eliminated, and although it would reduce over time, the degree of reduction would not be monitored. Cross-media effects may be anticipated with Alternative GW-1. Although contaminated groundwater has not been detected in the unnamed creek, cross-media effects may result if contaminants discharge in the future.

Compliance with ARARs. Alternative GW-1 would not comply with chemical-specific ARARs (i.e. Florida GCTLs) in the short term. This alternative may eventually comply with ARARs if natural processes including physical, chemical, and biological changes in the aquifer reduce contaminant concentrations, but compliance would not be verified.

Long-Term Effectiveness and Permanence. Naturally occurring processes, such as biological activity, may reduce contaminate concentrations in the shallow zone of the surficial aquifer over the long term. However, risks due to potential future ingestion of groundwater (by residents) would not be addressed via treatment and could remain over the long term until natural processes reduce concentrations. The processes will not be monitored and therefore unknown.

Reduction of Toxicity, Mobility, and Volume through Treatment. Although no treatment is included in this alternative, it would provide some reduction in contaminant toxicity and volume of VOCs through ongoing natural degradation processes in the surficial aquifer. However, this alternative would not provide a reduction in contaminant mobility in the aquifer because no groundwater extraction or treatment is proposed.

No treatment residual would be produced if this alternative is implemented.

Short-Term Effectiveness. This alternative would have no short-term impact on the environment and surrounding community since no action would be implemented. Because this alternative does not include active treatment of the contaminated groundwater at PSC 51, the time required to reach RAOs is unknown. The cost estimate for no action is based on 30 years of implementation, although the actual duration is unknown. The default value of 30 years will be used as suggested by USEPA guidance (USEPA, 1988).

Implementability. This alternative does not require implementation, this alternative is already in place.

Costs. There are no costs associated with Alternative GW-1 for PSC 51.

12.2.2 Alternative GW-2: Monitored NA

This alternative relies on NA to reduce the concentration of contaminants in the groundwater at PSC 51. A description of this alternative is presented in Subsection 12.2.2.1 and a technical criteria analysis of this alternative is presented in Subsection 12.2.2.2.

As discussed in the RI section of this report, a preliminary NA study was performed for PSC 51. The study was conducted during the RI for a comparative analysis of monitored NA with other remedial technologies. Based on a preliminary NA study, results indicate that anaerobic conditions prevail in the co-mingled petroleum and chlorinated solvent plume. The production of 1,2-DCE and vinyl chloride, which are breakdown products of TCE starting material, indicates that reductive dechlorination is active within the plume. Inorganic species analyses suggest that sulfate reduction is active in the core of the plume. Anaerobic destruction of petroleum products is very inefficient. However, its slow aerobic degradation consumes DO and helps maintain anaerobic conditions. Therefore, this process may require modification after time.

12.2.2.1 Detailed Description

NA relies on natural biological and physical/chemical processes occurring within the surficial aquifer to reduce contaminant concentrations in groundwater. Microorganisms within the aquifer use organic contaminants as substrate (food), processes such as volatilization, sorption, advection, and dispersion further reduce contaminant concentrations naturally within the aquifer.

The following components would be included as part of this alternative:

- Groundwater and surface water monitoring
- Biodegradation monitoring

- Groundwater reporting
- Groundwater use restrictions
- Five-year site reviews

The monitoring component of NA will assess the degradation and reduction of organics within the aquifer, thus allowing an evaluation of the effectiveness of NA as a treatment technology. Since groundwater contaminant modeling was not performed, a remedial cleanup time was estimated based on standard modeling techniques using the half-life of degrading contaminants. Benzene, the contaminant that exceeded its clean-up standard by the largest margin, was used to determine a remedial time of 10 years. The degradation rate of petroleum compounds is more easily predicated than for chlorinated compounds. The COCs, TCE and vinyl chloride, have wide ranging half-life degradation rates depending on the natural attenuation conditions at a site. Published degradation rates for TCE and vinyl chloride indicate a remedial cleanup time range of 5 to 35 years for TCE, and 4 to 21 years for vinyl chloride. Only after two to five years of natural attenuation, monitoring can a more accurate remedial cleanup time be predicted for the chlorinated compounds. Since contaminant plume modeling has not been performed, the administrative O&M cost estimate will be based on an assumed duration of 15 years.

Groundwater and Surface Water Monitoring. Groundwater would be monitored for parameters, which indicate the likelihood of ongoing and potential future biodegradation, in order to assess the effectiveness of NA as a treatment for the surficial aquifer at PSC 51. It is assumed that six existing wells throughout and downgradient of the plume, and a new well installed northeast of the groundwater plume would be used for groundwater monitoring to monitor plume size, chemical concentrations, and movement of the groundwater.

Groundwater monitoring would be performed quarterly the first year, semi-annually the second year and annually thereafter. Groundwater monitoring will continue until action levels are attained, unless it is determined during a five-year review of site conditions that a more aggressive alternative should be considered. A total of seven groundwater samples would be collected for analysis at PSC 51 during each round of sampling and analyzed for the following parameters, as suggested in the Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (USEPA, 1998a):

- TCL VOCs
- Sulfate, chloride, nitrate, and iron (II)
- Methane, ethane, and ethene
- Field measurements of ORP, pH, DO, hydrogen, alkalinity, conductivity, and temperature

Surface water monitoring would be performed in conjunction with the groundwater monitoring at PSC 51. The surface water monitoring will assure that groundwater discharges to the unnamed creek do not exceed surface water ARARs, and assist in determining plume migration. It is assumed that two surface water samples would be collected during each groundwater monitoring event and analyzed for TCL VOCs.

Measurement of these parameters over time at PSC 51 would assist in evaluating the extent of natural biodegradation, the overall conditions within the aquifer, and the relative migration of contaminants. The data will determine whether or not NA is effective in reducing chemical concentrations. A summary report would be prepared to present and evaluate the data collected during each monitoring event.

A more detailed NA study over an extended time frame would be required to produce an estimate of the time frame required for NA. The 10-year value will be used for this estimate.

Groundwater Use Restrictions. LUCIPs in the vicinity of PSC 51 would be annotated to indicate that groundwater extraction for potable use in the area may pose a significant health risk if consumed without treatment. The annotation would reference this RI/FS document, proposed plan, and ROD. The agency currently responsible for administering the well installation permit program would be formally requested not to issue permits for installation of potable wells screened in the surficial aquifer. Planning agencies, permitting agencies, and owners of property affected by the PSC 51 contaminants would be reminded annually of the groundwater use restrictions. These restrictions would be removed only when a five-year site review indicates, based on the groundwater monitoring program results, that the PSC 51 action levels have been achieved.

A Memorandum of Agreement (MOA) between the USEPA, FDEP, and the Navy was signed on August 31, 1998. The purpose of the MOA is to ensure compliance with Land Use Controls (either already in place, or selected for future remedial action) to protect human health and the environment from exposure to contaminated media at NAS Jacksonville, among other facilities. Therefore, groundwater use restrictions at PSC 51 shall be identified and enforced under the guidelines of the MOA (USEPA, 1998).

Groundwater Reporting. Groundwater reporting would be performed to document plume concentrations and NA conditions. The reporting would be updated after each monitoring event, based on the results of annual groundwater sampling or other pertinent data or site changes. If deemed necessary based on groundwater monitoring and reporting, groundwater modeling would be performed before the first five-year site review. The modeling will be used to estimate the duration of the remedial treatment as well as to evaluate contaminant degradation and distribution.

Five-Year Site Reviews. Because contaminated groundwater present at PSC 51 would be left in place as part of the NA alternative, the Navy, USEPA, and FDEP must conduct reviews of site conditions and determine that the continued implementation of this alternative is appropriate. Site reviews would occur every 5 years until the action levels are attained. Reviews will consist of evaluating groundwater monitoring data and compliance with ARARs, and assessing changes in site conditions (e.g., receptors, migration pathways, or qualitative risks). The appropriateness of this alternative would be compared to other remedial alternatives to confirm that this alternative remains the most appropriate selection.

12.2.2.2 Technical Criteria Assessment

The technical assessment of Alternative GW-2 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would provide a minimum standard of protection to future human receptors that may use PSC 51 groundwater as a potable water supply. During the treatment period, implementing groundwater use restrictions thereby controlling risk will prohibit exposure to contaminated groundwater. Humans would be prevented from developing a production well within the surficial aquifer at PSC 51.

No adverse short-term effects are anticipated as a result of implementing Alternative GW-2. Cross-media effect may occur as a result of implementing Alternative GW-2; however, surface water monitoring will be conducted to determine this possibility.

Compliance with ARARs. Alternative GW-2 would not comply with chemical-specific ARARs (i.e., Federal and Florida drinking water standards) in the short term. This alternative would eventually comply with ARARs when natural physical, chemical, and biological processes in the aquifer reduce contaminant concentrations over time. Groundwater reporting would be used to assess degradation of VOCs in groundwater and evaluate compliance with ARARs. Alternative GW-2 would not trigger location-specific or action-specific ARARs.

Long-Term Effectiveness and Permanence. Naturally occurring processes are expected to reduce contaminant concentrations in the aquifer over the long term. Since fate and transport modeling has not been performed for PSC 51, 15 years is the assumed time for NA of COPCs.

Groundwater monitoring will provide a means of evaluating the concentrations of VOCs in groundwater and assessing the degradation rate of contaminants. In addition, monitoring of indicator parameters within the aquifer will help to evaluate the effectiveness of NA in reducing VOC concentrations. Administrative actions proposed in this alternative will provide a means of exposure control, but will not provide a

permanent, irreversible remedy for risks posed by groundwater contamination. Groundwater monitoring and administrative actions are considered reliable controls.

Reduction of Toxicity, Mobility, and Volume through Treatment. Although no active treatment is included in this alternative, contaminant toxicity of VOCs would be reduced over time through natural degradation processes. As stated previously, further investigation will be necessary to determine the migration and degradation of contaminants in groundwater.

The potential for human health risks for potential residents would remain until natural processes reduce VOCs, although exposure will be limited by groundwater use restrictions.

The implementation of this alternative would present no additional risks to human receptors over baseline conditions. This is because treatment proposed by this alternative occurs in situ, making exposure to groundwater contamination limited. Furthermore, no treatment residuals would be produced by implementation of this alternative.

Short-Term Effectiveness. This alternative poses only a minimum risk to site workers through exposure to contaminated groundwater during monitoring activities. This risk would be addressed through adherence to proper health and safety procedures. This alternative is expected to comply with RAOs in 30 years.

Implementability. Alternative GW-2 does would require construction activities for implementation. Monitoring equipment would be easily obtained, and groundwater and surface water monitoring and modeling, five-year site reviews, and groundwater use restrictions would be easily implemented.

Cost. Estimated costs for Alternative GW-2 would be as follows:

- Capital Cost: \$25,000
- Present Worth of O&M Cost \$309,000
- Net Present Worth \$384,000

A detailed cost breakdown is provided in Appendix M.

12.2.3 Alternative GW-3:Enhanced Biodegradation

This alternative consists of injecting nutrients into the groundwater plume to enhance natural biodegradation of VOCs, primarily benzene, 1,2-DCE, vinyl chloride, ethylbenzene, toluene, xylenes, and

naphthalene. A description of this alternative is presented in Subsection 12.2.3.1, and a technical criteria analysis of this alternative is presented in Subsection 12.2.3.2.

12.2.3.1 Detailed Description

This alternative, enhanced biodegradation, would be achieved by enhancing natural bacterial biodegradation of organic contaminants. As stated in section 7.0 of this report, the introduction of oxygen releasing compounds into the plume would help favor aerobic biodegradation, thereby speeding up the time for degradation of all VOCs, except for 1,1-DCE and TCE. Enhanced biodegradation is accomplished by introducing nutrients to stimulate bacterial growth and speed up biodegradation of organic compounds. Enhanced biodegradation treatability testing has not been performed at PSC 51 and would be required to assess the effectiveness of this technology.

For this FS, it is assumed that an oxygen-releasing compound is the nutrient that would be used to enhance the rate of in-situ aerobic biodegradation of benzene, 1,2 DCE, vinyl chloride, ethylbenzene, toluene, xylenes, and naphthalene in the groundwater plume. Due to the presence of both benzene and the “daughter” chlorinated organic compounds, an oxygen-releasing compound is assumed to be the most effective compound for enhanced biodegradation (USEPA 1998a). The following components would be included as part of this alternative:

- Oxygen-releasing compound injection
- Groundwater, surface water and biodegradation monitoring
- Groundwater use restrictions
- Treatability studies
- Five-year site reviews

Each of the components of this alternative is described in greater detail in the following paragraphs.

The Oxygen-Releasing Compound Injection System. This alternative would feature injection of an oxygen-releasing compound into the groundwater contaminant plume to enhance the natural biodegradation of VOCs under aerobic conditions. Currently, at PSC 51 anaerobic conditions prevail and the introduction of oxygen releasing compounds would help encourage aerobic degradation. Oxygen-releasing compounds would be injected by hollow-stem auger or DPT methods or injected through groundwater monitoring wells. For this FS, as recommended by an oxygen-releasing compound vendor (Regenesis), it was assumed that DPT would be used to create 300 boreholes for the injection of oxygen-releasing compound, with the oxygen-releasing compound injected over the wetted interval in the borehole. The “ballpark” compound injection rate as recommended by Regenesis is 2 lbs per ft, or 40 lbs per injection point and 12,000 lbs total for the first application.

The oxygen-releasing compound would be injected into the plume area through injection points arranged in a grid pattern over the benzene plume area. The compound would be injected over the full depth of the contaminated saturated zone. It is assumed that oxygen-releasing compound would be injected from 5 ft to 40 ft bls at 10 ft spacing between rows over the entire area of the plume, which totals 300 points. Injection at the source area is estimated to require a second application one-third the size of the first application one year after the initial application. Additional information for the application of the oxygen-releasing compound is included in Appendix L.

The oxygen-releasing compound vendor estimated the oxygen-releasing compound dosage required for implementing this alternative. The oxygen-releasing compound usage is based on the following criteria:

- The initial dosage of oxygen-releasing compound will be followed by one additional dosage, which will be injected one year after the initial dosage.
- A grid pattern injection system will be used.
- 1-inch boreholes would be used for the oxygen-releasing compound injection points.

Groundwater, Surface Water and Biodegradation Monitoring. Groundwater would be monitored for parameters, which indicate the likelihood of ongoing and potential future biodegradation, in order to assess the effectiveness of enhanced biodegradation as a treatment for the surficial aquifer at PSC 51. It is assumed that the existing wells and a new well installed northeast of the groundwater plume would be used in the groundwater monitoring program. Surface water monitoring would be conducted in conjunction with groundwater monitoring from two locations to assure COCs are not discharging during the long term monitoring.

In order to effectively assess the performance of oxygen-releasing compound injection and confirm that biodegradation is occurring, monitoring would be performed quarterly the first year after oxygen releasing compound injection. Groundwater monitoring would be continued annually for the second through fifth year until the five-year site review. It is assumed that the treatment duration for this alternative would be 5 years, which should include the time required to achieve GCTLs and time for rebound monitoring. It should be noted that the five year assumption could change based on the performance of the treatability study.

Analytical results from groundwater sampling conducted during the RI indicate a select number of compounds at PSC 51 at concentrations exceeding their respective ARARs/TBCs (Table 10-3). Therefore, the quarterly monitoring program for evaluating enhanced biodegradation would include groundwater sampling and analysis for TCL VOCs. Sampling and analysis of the NA parameters

specified in Subsection 12.2.2.1 will also be conducted. Measurement of these parameters over time would help determine whether or not enhanced biodegradation is effective in reducing chemical concentrations and ultimately reducing risks to hypothetical resident human receptors. The number of groundwater samples to be collected would be seven, from existing wells. A summary report would be prepared to present and evaluate the data collected during each annual monitoring event.

If this alternative is selected a groundwater monitoring plan would be prepared detailing sampling frequency and the analytical program. This plan will be submitted for regulatory review and approval prior to implementation.

Groundwater Use Restrictions. This component would be identical to the groundwater use restrictions described for Alternative GW-2.

Treatability Studies. If this alternative is implemented at PSC 51, pilot-scale tests would be necessary to collect design information for implementing full-scale applications of this technology. The pilot study would be designed to establish 1) the quantity of oxygen-releasing compound needed for full scale implementation, 2) an estimated treatment duration, and 3) the optimum placement of oxygen-releasing compound injection points.

Five-year Site Reviews Five-year reviews would be identical to those described for Alternative GW-2. In addition to these activities, treatment performance would be summarized and evaluated. The summary would include monitoring results, an assessment of the reduction in contaminant concentrations in the groundwater and an evaluation of compliance action levels.

12.2.3.2 Technical Criteria Assessment

The technical assessment of Alternative GW-3 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would provide protection to future human receptors that may use PSC 51 groundwater as a potable water supply. Humans would be protected in the short term because groundwater use restrictions will prohibit the consumption of water from the aquifer until complete aquifer restoration (i.e., when action levels are achieved). Injection of oxygen-releasing compound would enhance the ongoing NA of contaminants in the surficial aquifer. This reduction in VOC concentrations would eventually eliminate human health risks associated with the groundwater. However, the concentrations of TCE and 1,1-DCE may not be effected by the enhanced biodegradation treatment. The combination of in-situ groundwater treatment and groundwater use restrictions would ensure that human health is properly protected in both the short and long term.

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. Implementation of this alternative would achieve chemical specific ARARs for VOCs in the groundwater through enhanced biological mechanisms. Groundwater monitoring is included in this alternative to evaluate compliance with ARARs.

This alternative would comply with action-specific ARARs, such as the Federal and State regulations for underground injection control.

Long-Term Effectiveness and Permanence. Enhanced biodegradation is an emerging technology that has been shown to be effective at biologically destroying VOCs permanently, when NA has been occurring at the selected site. Pilot studies performed at other sites and available vendor information can provide assistance on assessing the ability of oxygen-releasing compound to enhance the biodegradation VOCs. However, if this alternative is selected for PSC 51, field tests would be required to optimize injection distribution and quantity of oxygen-releasing compound injections.

Reduction of Toxicity, Mobility, and Volume through Treatment. This alternative will accelerate reduction in toxicity and volume of VOCs in groundwater by enhancing the natural degradation processes. During degradation, enhanced biodegradation will not provide a significant reduction in contaminant mobility. However, the estimated duration of treatment is only five years at PSC 51, and therefore significant migration of the plume before biological destruction is not likely.

Enhanced biodegradation would biologically destroy the VOCs in-situ in the groundwater plume. Therefore, no treatment residuals would be produced by this alternative.

Short-Term Effectiveness. There will be minimal exposure risk to workers installing the boreholes for oxygen-releasing compound injection if DPT is utilized. Remedial construction activities are not proposed under this alternative. This alternative poses only a minimum threat to site workers through exposure to contaminated groundwater during injection and monitoring activities and the proper use of health and safety procedures will reduce these risks. These activities would not pose a risk to the community. It is anticipated that a treatment duration of five years would be required at PSC 51 to comply with RAOs.

Implementability. Injection of oxygen-releasing compound would require only basic drilling techniques. Injection points at PSC 51 are located in an unused and cleared area at NAS Jacksonville, and manmade structures would not interfere with drilling.

Equipment required for groundwater monitoring is easily obtained. Groundwater monitoring, groundwater use restrictions, and five-year site reviews are easily implemented.

Cost. Estimated costs for Alternative GW-3 would be as follows:

- Capital Cost: \$365,000
- Present Worth of O&M Cost \$180,000
- Net Present Worth \$600,000

The above figures were rounded to the nearest \$1,000 to reflect the preliminary nature of the estimates. A detailed cost breakdown is provided in Appendix M.

12.2.4 Alternative GW-4:In-situ Chemical Oxidation

This alternative would consist of injecting an oxidant into the groundwater at PSC 51 to chemically destroy the chlorinated compounds and petroleum compounds. A description of this alternative is presented in Subsection 12.2.4.1 and a technical criteria analysis of this alternative is presented in Subsection 12.2.4.2.

12.2.4.1 Detailed Description

For the purpose of detailed analysis of the chemical oxidation alternative, it was assumed that hydrogen peroxide would be the oxidant injected into the aquifer to destroy the VOCs. Based on published literature, it was anticipated that chemical oxidation with hydrogen peroxide would be able to destroy up to 90 to 99 percent of the contaminant mass.

The following components will be included in the chemical oxidation alternative:

- Treatability study
- Oxidant injection
- In-situ chemical oxidation
- Groundwater and surface water monitoring
- Groundwater use restrictions
- Five-year site reviews

Each of the components of this alternative is described in greater detail in the following paragraphs. Vendor information used to develop this alternative is included in Appendix L.

Treatability Studies. If this alternative is implemented at PSC 51, a pilot-scale test would be necessary to collect information for implementation of a full-scale application. The pilot study would be designed to establish: (1) the feasibility of injecting and adequately distributing the solution in the contaminated area, (2) an estimate of destructive efficiency, and (3) the optimum concentration of oxidant in the solution.

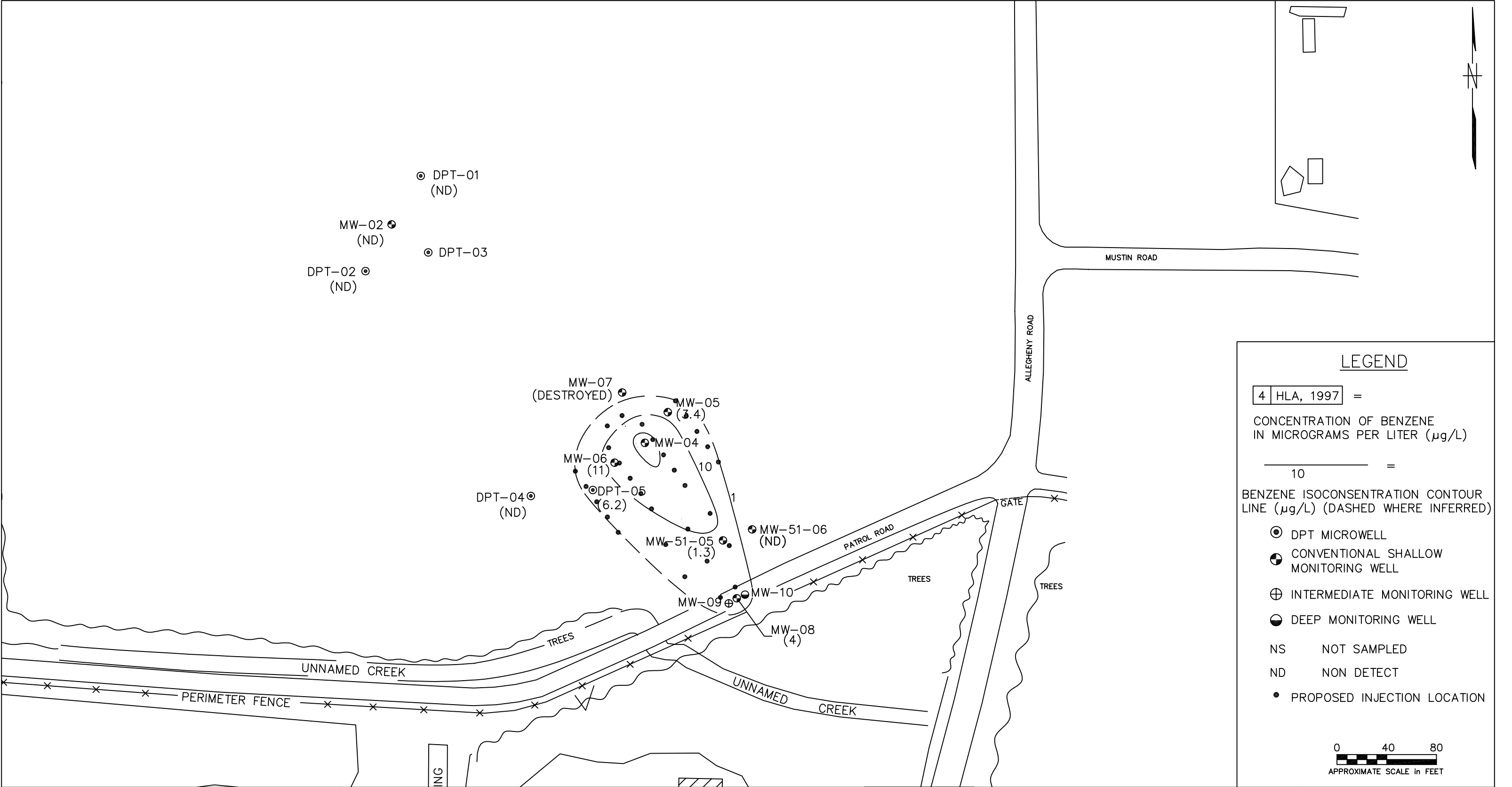
Oxidant Injection. Steel injection wells would be installed and used for chemical oxidation of the contaminated groundwater at PSC 51. The groundwater would be injected with H_2O_2 in 30 special injection wells screened at a depth from 5 to 30 ft bls. For the purpose of this FS, a ballpark estimate was provided by a chemical oxidation vendor. This initial estimate includes the following preliminary design assumptions: a 15 ft injector effective radius of influence for each injection well, 30 injection wells, and a total of 60,000 lbs of hydrogen peroxide required injected at a rate of 8,000 lbs per day. A chemical oxidation pilot test would be performed to determine the actual site specific injection criteria.

In-Situ Chemical Oxidation. Chemical oxidation using Fenton's Reagent oxidizes contaminants via hydrogen peroxide. In Fenton's reaction, hydrogen peroxide reacts with ferrous iron to produce the hydroxyl radical, a powerful oxidizer. The hydroxyl radical progressively reacts with organic compounds to produce carbon dioxide and water. When the oxidized organic compound is chlorinated, chloride ions are also released. Published research shows that in-situ chemical oxidation using Fentons Reagent can be an effective remediation technology at chlorinated VOC sites. Figure 12-1 illustrates proposed chemical oxidation injection point locations.


The reagent is pumped into the injection wells under pressure. The anticipated dosage of the reagent for chemical oxidation of VOCs at PSC 51 is 60,000 lbs, as a rough estimate provided by a vendor (Appendix L). The estimated treatment duration is less than one year. The treatability study would determine the actual number of injection points and duration to adequately treat the contaminated groundwater.

Groundwater and Surface Water Monitoring. Groundwater would be monitored in order to assess the effectiveness of chemical oxidation as a treatment for the surficial aquifer at PSC 51. It is assumed that the existing wells and a new well installed northeast of the groundwater plume would be used in the groundwater monitoring program.

In order to effectively assess the performance of chemical oxidation injection and confirm that destruction of COPCs has occurred, monitoring would be performed quarterly after the first year of chemical oxidation compound injection. It is assumed that the treatment and monitoring duration for this alternative would be 2 years, which would include quarterly monitoring and chemical oxidation injection the first year, and one year of post quarterly monitoring. Surface water monitoring would be conducted in conjunction with the



NO.						DATE						REVISIONS						BY	CHKD	APPD	REFERENCES						DRAWN BY		DATE	
																											CW		9/25/00	
																											CHECKED BY		DATE	
																											COST/SCHED-AREA			
																											SCALE			
																											AS NOTED			



PROPOSED LOCATIONS OF INJECTION FOR
CHEMICAL OXIDATION
CHEMICAL OXIDATION ALTERNATIVE
PSC 51
NAS JACKSONVILLE
JACKSONVILLE, FLORIDA

CONTRACT NO.		N0253	
APPROVED BY		DATE	
APPROVED BY		DATE	
DRAWING NO.		REV.	
FIGURE 12-1		0	

groundwater monitoring. It should be noted that the two-year assumption could change based on the performance of the treatability study.

Groundwater Use Restrictions. Groundwater use restrictions would be similar to those described in Alternative GW-2.

Five-year Site Reviews. Five-year site reviews would be similar to those described in Alternative GW-2. The summary will include monitoring results, an assessment of the reduction in contaminant concentrations in the groundwater, and an evaluation of compliance action levels.

12.2.4.2 Technical Criteria Assessment

The technical assessment of Alternative GW-4 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would provide protection to future human receptors that may use PSC 51 groundwater as a potable water supply. Humans would be protected in the short term because groundwater use restrictions would prohibit the consumption of groundwater until complete aquifer restoration (i.e., when action levels are achieved). The chemical oxidation process would quickly reduce VOC concentrations in groundwater down to acceptable levels within one year. The combination of in-situ groundwater treatment and groundwater use restrictions would ensure that human health is properly protected in both short and long term.

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. It is expected that implementation of the chemical oxidation alternative would eventually comply with chemical-specific ARARs for the VOCs at PSC 51. Groundwater monitoring would be incorporated to ensure compliance with chemical specific ARARs. The chemical oxidation alternative would also comply with location and action specific ARARs.

Long-Term Effectiveness and Permanence. This alternative would offer a long-term and permanent remedy for VOC contamination in groundwater. Chemical oxidation has been proven effective in the destruction of VOCs in groundwater. A treatability study would be required to establish site-specific performance and oxidant dosing prior to implementing this remedial technology.

Groundwater use restrictions would prevent human consumption of groundwater until the action levels for VOCs are achieved, and the potential risk to future residents is eliminated. Groundwater monitoring would provide a means of evaluating the concentrations of contaminants in groundwater over time.

Reduction of Toxicity, Mobility, and Volume through Treatment. This alternative would reduce the toxicity, mobility, and volume of VOCs in the groundwater at PSC 51. This alternative would be accomplished through the chemical destruction of VOCs in-situ by chemical oxidation.

There would be no residuals produced by the implementation of this alternative.

Short-Term Effectiveness. There would be only slight exposures to workers performing installation of injection wells and groundwater monitoring. These activities would not pose a significant risk to workers or the community if the proper health and safety procedures are followed. It is estimated that RAOs would be achieved within two years.

Implementability. Injection of the oxidant would require special techniques that must be provided by a few vendors. This technique is more difficult to implement than typical drilling operations. Injection points at PSC 51 are located in an unused, cleared area at NAS Jacksonville, and manmade structures would not interfere with drilling.

Equipment required for groundwater monitoring would be easily obtained. Groundwater monitoring, groundwater use restrictions, and five-year site reviews are easily implemented.

Cost. Estimated costs for Alternative GW-4 would be as follows:

- Capital Cost: \$381,000
- Present Worth of O&M Cost \$161,000
- Net Present Worth \$813,000

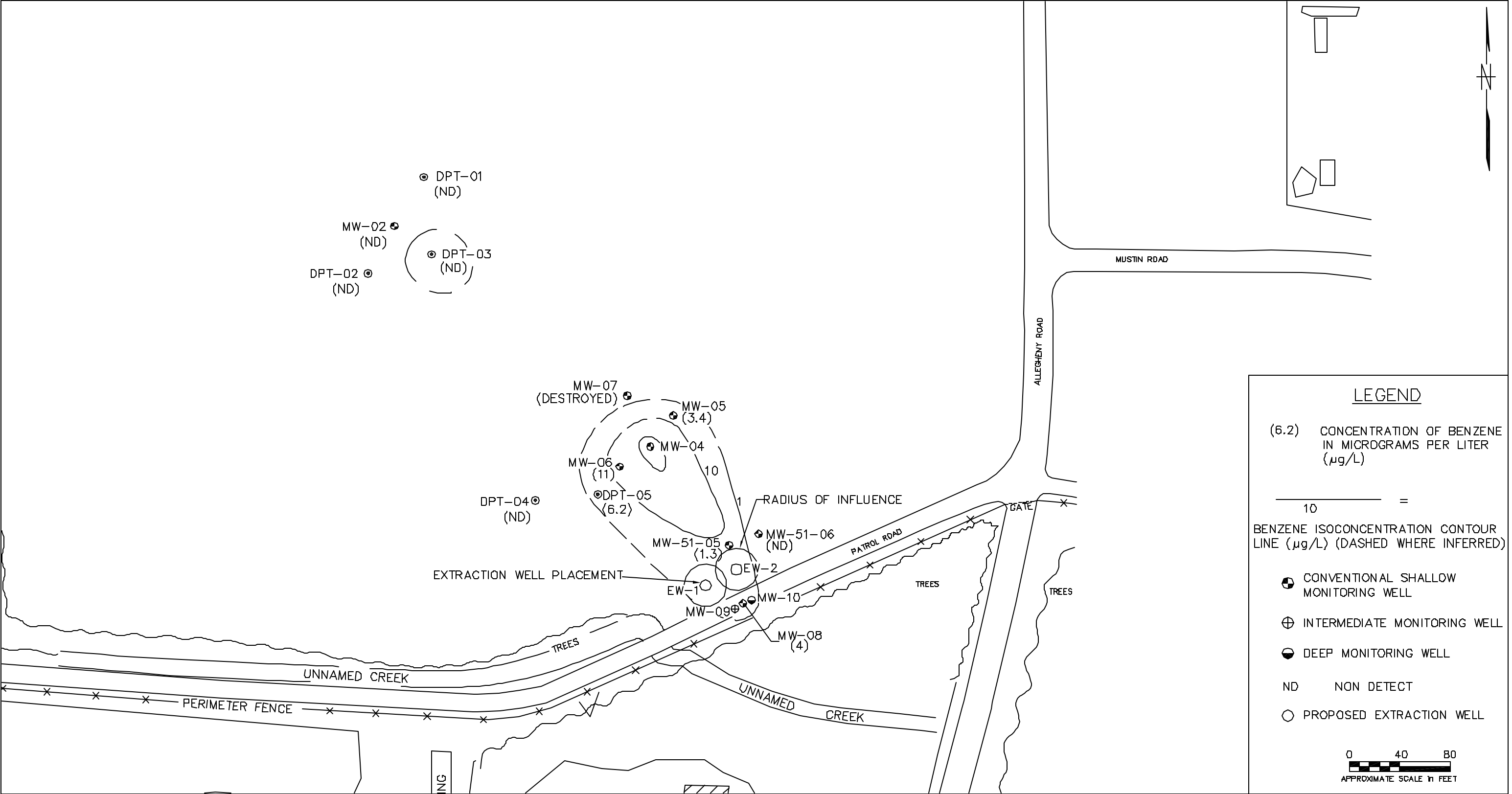
A detailed cost breakdown is provided in Appendix M.

12.2.5 Alternative GW-5: Extraction-and-Treatment

This alternative consists of implementing a groundwater extraction-and-treatment system to encompass the VOC plume.

12.2.5.1 Detailed Description

This alternative would consist of collecting groundwater through extraction wells, providing treatment to achieve appropriate criteria and discharging the treated effluent to the FOTW. For the purposes of alternative development and cost estimating, it was assumed that the FOTW would be the receiving body.



NO.		DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE	CONTRACT NO.	
								CW	9/19/00	N0253	
								CHECKED BY	DATE	APPROVED BY DATE	
								COST/SCHED-AREA		APPROVED BY DATE	
								SCALE		DRAWING NO.	
								AS NOTED		FIGURE 12-2	
										REV.	
										0	

A plan review showing the proposed location of the extraction well is shown on Figure 12-2. The following components would be included in this alternative:

- Groundwater extraction
- Hydrogeologic study
- Air stripping
- Treated groundwater discharge
- Groundwater use restrictions
- Groundwater and system monitoring
- Five-year site reviews

Groundwater modeling and treatability studies have not been performed for PSC 51. Based on preliminary contaminant removal calculations, it was estimated that it would take four years to remove contaminants. Since extraction and treatment times can widely vary from site to site, and a site specific hydrogeological study has not been performed, a conservative cleanup time of eight years was used for this FS, assuming treatment for eight years and quarterly monitoring one year after.

Groundwater Extraction. Contaminated groundwater would be extracted through two extraction wells (EW-1, EW-2) to capture the plume for a barrier scenario. Based on pump results from the Remedial Action Plan for the FFTA at NAS Jacksonville (TtNUS, 1999b), it was assumed that an estimated groundwater recovery rate of 3 gpm per well can be sustained, and that the radius of influence for a groundwater extraction well at this rate is 30 ft. The estimated 6 gpm total flow rate is adequate for use with a typical aeration treatment system to efficiently remove hydrocarbons with moderate O&M. The wells would be placed between monitoring wells MW-51-0-5 and MW-08. The extraction wells would be four inches in diameter, 40 ft deep and would be constructed of schedule 40 polyvinyl chloride (PVC). Groundwater would be pumped from the wells at a rate of 3 gpm per well for a total extraction rate of up to 6 gpm. Based on the calculations provided in Appendix L, It is assume that it would take four years for groundwater in the aquifer would be restored to the action levels. However, extraction and treatment systems typically require an extended period of time to meet the required action levels and therefore it was assumed that eight years is a more accurate remedial time. Refer to Appendix L for design calculations. The anticipated zones of influence and capture zones calculations are also included in Appendix L. The actual placement of the extraction well or wells would be determined through hydrogeologic modeling.

Hydrogeologic Study. If this alternative is selected for PSC 51, site-specific hydrogeological studies would be necessary during the design phase to verify estimated pumping rates, capture zones, and well designs and depths based on the aquifer test, flow gradient, and plume width. For the purpose of this FS,

the USGS pumping test conducted at NAS Jacksonville was used as a rough estimate. The placement and design of the extraction well(s) would be refined during the remedial design stage based on the treatability study.

In most extraction-and-treatment systems, stagnation zones of negligible groundwater flow occur between wells. Changing the pumping rates for each well during implementation to promote more efficient aquifer flushing could minimize these zones. The hydrogeologic study would help minimize these zones.

Air Stripping. If deemed necessary by initial full-scale testing, a filter system would be used for the extracted groundwater to prevent suspended solids from collecting (and potentially fouling) the packing material. After pH adjustment, extracted groundwater would be treated in a packed tower air stripper. An alternative air stripper may be substituted. If necessary an off gas treatment system (GAC) would be used to polish the groundwater before discharge. Based upon concentrations of VOCs detected in groundwater, such an offgas system should not be required since the total estimated VOC emissions from the air stripper (0.015 lbs per day maximum) would be well below the FDEP threshold value for emissions controls (13.7 lbs per day).

Treated Groundwater Discharge. Treated groundwater would be discharged to the FOTW. A building is located approximately 2,000 ft to the east of PSC 51, where the treatment system could be connected to the sanitary sewer. Treated water discharge would be required to satisfy the substantive requirements of the FOTW. The groundwater contaminants are less than two fold of the effluent standards of the FOTW. The efficiency rating of an air stripper at a conservative estimate of 90 percent would amply satisfy the effluent standards of the FOTW. Sampling and analysis of the discharge stream would be performed to ensure compliance with these criteria.

Groundwater, Surface Water, and System Monitoring. This component would be similar to the monitoring performed as part of Alternative GW-2. In addition to the groundwater monitoring activities, effluent monitoring and the treatment effectiveness and the operation of the extraction-and-treatment system would be monitored. Operational activities would include pH adjustment, system cleaning, sludge management, and other process maintenance requirements.

Groundwater Use Restrictions. This component would be identical to the groundwater use restrictions for Alternative GW-2.

Five-Year Site Reviews. This component would be similar to the five-year site reviews performed as part of Alternative GW-2. In addition to these activities, treatment performance would be summarized and evaluated. This evaluation would include an assessment of the reduction in VOC concentrations in the

groundwater, an evaluation of compliance with action levels, and a review of the effectiveness of extraction-and-treatment.

12.2.5.2 Technical Criteria Assessment

The technical assessment of Alternative GW-5 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would provide protection to future users of PSC 51 surficial aquifer contaminated groundwater as a potable water supply through use restrictions. These restrictions would remain in place until action levels are achieved. Additionally, contaminated groundwater would be removed from the aquifer and treated. This alternative provides a maximum standard of protection to humans (i.e., groundwater treatment).

Compliance with ARARs. This alternative would comply eventually with all chemical specific ARARs. Groundwater would be removed and treated until required treatment levels are achieved. Extracted groundwater would be treated at the FOTW. Action-specific and location-specific ARARs would be met by this alternative.

Long-Term Effectiveness and Permanence. This alternative would offer a long-term, permanent remedy for groundwater contamination, without relying on natural transformation processes.

Extraction and treatment via air stripping would reduce organic contaminant concentration. Groundwater use restrictions would also prevent human consumption of groundwater until action levels are achieved. Groundwater monitoring would provide a means of evaluating the concentrations of contaminants in groundwater over time.

Reduction of Toxicity, Mobility, and Volume through Treatment. This alternative reduces the toxicity, mobility, and volume of VOCs in extracted groundwater. VOCs would be volatilized in the air stripper. Residuals produced through this alternative (e.g., sludge and spent carbon) would be collected for off-site transport, treatment, and disposal at a permitted facility.

Short-Term Effectiveness. Installation of extraction wells, treatment of the groundwater, and discharge to surface water would not pose a significant risk to workers, as long as health and safety plans are adhered to. This alternative is expected to achieve RAOs in eight years, and a total duration time with monitoring of nine years. In addition, contaminated groundwater would be collected and treated, thus reducing the rate of downgradient contaminant migration through the aquifer and discharge to the unnamed creek.

Implementability. Installation of extraction and treatment systems is fairly common. Monitoring equipment is easily obtained and groundwater monitoring, five-year site reviews, and groundwater use restrictions are easily implemented.

Cost. Estimated costs for Alternative GW-5 would be as follows:

- Capital Cost: \$266,000
- Present Worth of O&M Cost \$504,000
- Net Present Worth \$1,003,000

A detailed cost breakdown is provided in Appendix M.

12.2.6 Alternative GW-6: Air Sparging

This alternative consists of sparging air into groundwater at PSC 51 to enhance volatilization of the VOCs and comply with ARARs. A description of this alternative is presented in Subsection 12.2.6.1 and a technical criteria analysis of this alternative is presented in Subsection 12.2.6.2.

12.2.6.1 Detailed Description

This alternative is intended to reduce concentrations of organic compounds in groundwater in-situ. AS would consist of installing air sparge wells and an aeration system to create turbulence in the groundwater and induce the mass transfer of the VOCs from water into the vapor phase.

The following components would be included in the AS alternative:

- Air Sparging
- Groundwater monitoring
- Groundwater use restrictions
- Treatment system monitoring
- Treatability studies
- Five-year site reviews

Each component of this alternative is described in greater detail in the following paragraphs.

Air Sparging. The AS system would feature 11 sparging wells. The sparge wells would be constructed with 2-inch inside diameter schedule 40 PVC with a screen at the bottom of each well. The well screens should be installed to a total depth below the bottom of the groundwater plume, estimated at 40 ft bls.

Assumptions for the radius of influence (ROI), injection pressure, and flow rate were made based on the Remedial Action Plan for the FFTA (TtNUS 1999a). The sparging ROI was used to establish a quantity and layout of injection wells that would sufficiently deliver injected air to the groundwater plume. The following parameters were estimated for installation of the AS system:

The proposed arrangements of the air sparge wells is indicated on Figure 12-3 and the design calculations are presented in Appendix L.

Typical remedial action duration for AS systems ranges from one to five years. For the purpose of this FS, it was assumed that remedial action duration would be five years.

It is anticipated that the generated vapors from AS would fall well below the Florida Air Emission Standards (maximum of 13.7 lbs of VOCs per day) at approximately 0.02 lbs per day. Additionally, it was determined that since the surface of PSC 51 is not impeded by any type of pavement or asphalt, a vapor extraction system would be unnecessary.

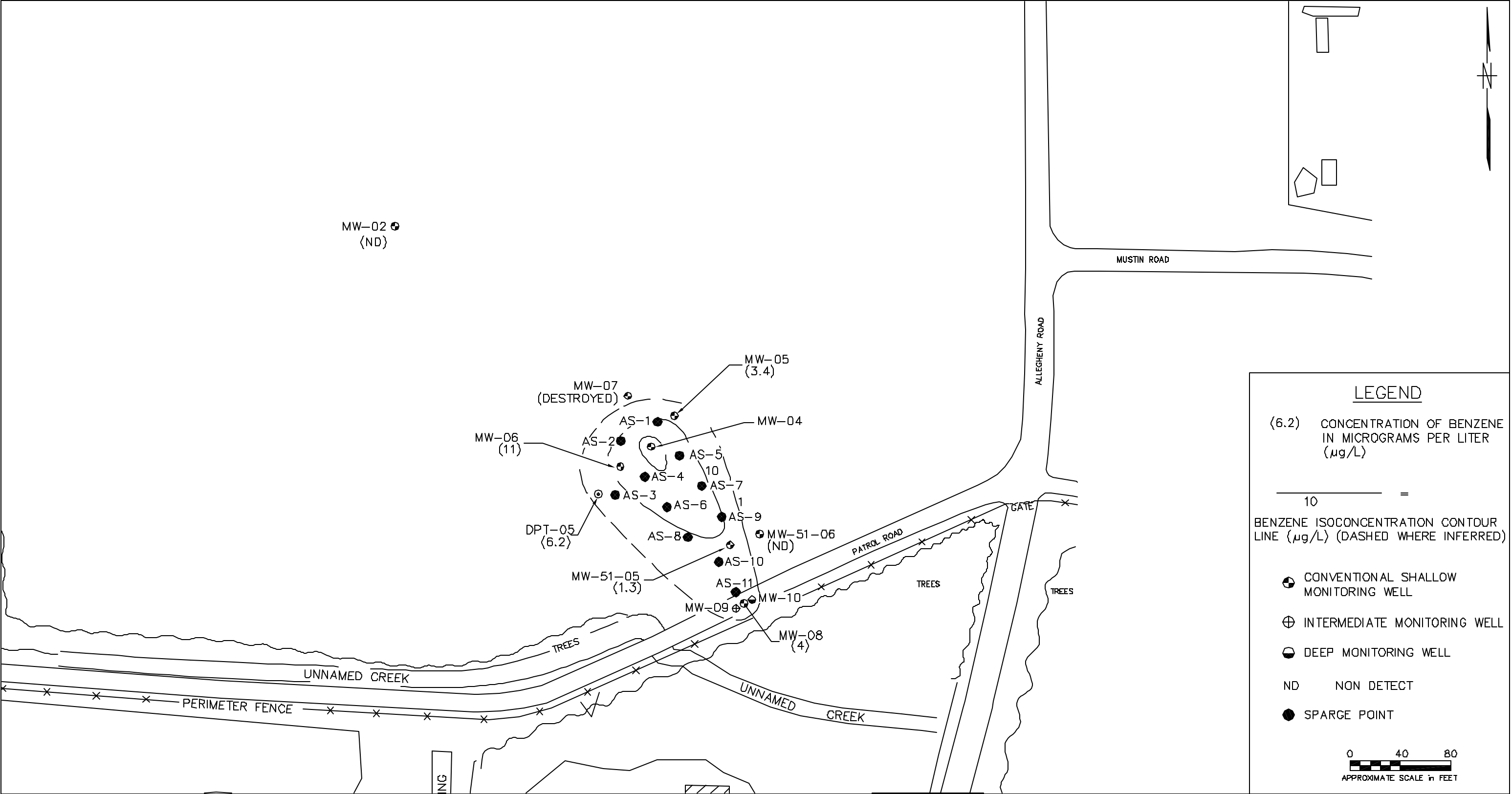
Groundwater and Surface Water Monitoring. Groundwater monitoring would be identical to that for Alternative GW-2.

Groundwater Use Restrictions. Groundwater use restrictions would be the same as for Alternative GW-2 .

Treatment System Monitoring. In addition to monitoring the groundwater, the operations of the AS system would be monitored on a regularly scheduled basis throughout remedy implementation. System monitoring activities would include measurement and adjustment of sparged air flow rate and system pressure, as well as inspection of the mechanical integrity of the system components. It is anticipated that an observational approach would be used to continually modify the applicable elements of the design (i.e., flow rates and pressure for air injection) based on system performance.

Treatability Study. A treatability study may not be required if this alternative is implemented since AS is such a well-demonstrated technology. However, for a conservative estimate a treatability study has been included. The pilot-scale test would be necessary to collect design information for implementing full-scale applications of this technology. The pilot study would be designed to establish: 1) AS pressures and flow rates to adequately distribute injected air to the groundwater plume, 2) the optimum placement of air injection wells, and 3) appropriately sized compressors for AS.

Five-Year Site Reviews. Five-year site reviews would be similar to those for Alternative GW-2. In addition to these activities, treatment system performance would be summarized and evaluated. This



NO.		DATE		REVISIONS		BY	CHKD	APPD	REFERENCES		DRAWN BY		DATE		CONTRACT NO.	
											CW		9/19/00		N0253	
											CHECKED BY		DATE		APPROVED BY	
											COST/SCHED-AREA				APPROVED BY	
											SCALE				DRAWING NO.	
											AS NOTED				FIGURE 12-3	
															REV.	
															0	

evaluation would consist of an assessment of the reduction in contaminant concentrations in the groundwater, an evaluation of compliance with action levels, and a review of the effectiveness of AS.

12.2.6.2 Technical Criteria

The technical assessment of Alternative GW-6 is provided in the paragraphs below.

Overall Protection of Human Health and the Environment. This alternative would provide protection to future human receptors who may use PSC 51 groundwater as a potable water supply. Humans would be protected in the short term because groundwater use restrictions would prohibit the consumption of water from the aquifer until complete aquifer restoration (i.e. when action levels are achieved). The AS process would eventually reduce VOC concentrations, eliminating human health risks.

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. This alternative would eventually comply with chemical-specific ARARs for VOCs. Annual groundwater monitoring is incorporated to ensure compliance with chemical-specific ARARs. The AS alternative would also comply with location and action-specific ARARs.

Long-Term Effectiveness and Permanence. This alternative would offer a long-term and permanent remedy for VOC contamination in groundwater. AS would physically and permanently remove the VOCs. AS is a proven and readily available technology for the removal of petroleum hydrocarbons. Engineering performance testing conducted at other areas of NAS Jacksonville (HLA 2000) indicated that AS was generally effective at removing chlorinated organic compounds from the groundwater. Because the groundwater contamination at PSC 51 lies within similar strata in the shallow zone of the surficial aquifer, AS is anticipated to be effective for PSC 51 as well.

Groundwater use restrictions would prevent human consumption of groundwater until the action levels for VOCs are achieved and the potential risks to hypothetical future residents is eliminated. Groundwater monitoring would provide a means of evaluating the concentrations of contaminants in groundwater over time.

Reduction of Toxicity, Mobility, and Volume through Treatment. This alternative would be accomplished through injection of air into the shallow zone of the surficial aquifer to volatilize the VOCs. AS would reduce the toxicity and volume of VOCs in the groundwater at PSC 51. Treatment of VOCs in groundwater by AS would remove the VOCs from groundwater, but the chemicals would not be destroyed and their toxicity would remain.

Extracted vapors at PSC 51 are not expected to exceed Florida air emission standards (maximum 13.7 lbs per day).

Short-Term Effectiveness. It is estimated that achieving action levels for this in-situ remedial alternative would require five years of system operation at PSC 51. There would be only slight exposures to workers performing installation of sparging wells, operation and maintenance, and annual groundwater monitoring. These activities would not pose a significant risk to workers or the community. No residuals would be produced from this alternative.

Implementability. Construction of an AS system is relatively easy to implement, requiring only basic construction practices and readily available equipment. Equipment required for groundwater and system monitoring is easily obtained, groundwater use restrictions, and five-year site reviews are easily implemented.

Costs. Estimated costs for Alternative GW-6 would be as follows:

- Capital Cost: \$322,000
- Present Worth of O&M Cost \$291,000
- Net Present Worth \$736,000

A detailed cost breakdown is provided in Appendix M.

13.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Remedial alternatives for PSC 51 were developed in Section 11.0 and were individually evaluated in Section 12.0 using the technical criteria recommended by the NCP. For comparative purposes, NCP criteria are grouped into the following categories:

- Threshold criteria
- Primary balancing criteria
- Modifying criteria

As presented in Section 12.0, only the first two sets of criteria are evaluated during the FS. The final set of criteria (i.e., modifying criteria consisting of State and community acceptance) is more appropriately evaluated after the public comment period for the proposed plan. This section presents a comparison of remedial alternatives with respect to threshold and primary balancing criteria by medium.

This comparison is intended to provide technical information required supporting the selection of a preferred alternative. It is anticipated that modifying criteria (i.e. State and community acceptance) would be used in conjunction with the information presented herein to select appropriate remedial alternatives in the ROD for PSC 51.

The following sections present the overall approach to comparative analysis and the comparative analysis of remedial alternatives for surface soil (Section 13.1) and groundwater (Section 13.2). A preliminary recommendation of remedies is presented in Section 13.3.

13.1 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SURFACE SOIL

Table 13-1 presents the comparative analyses of soil remedial alternatives against the seven criteria. This summary highlights the results of the detailed analysis and compares the extent of compliance for the purpose of identifying a preferred alternative.

13.1.1 Comparison of Threshold Criteria

The risks identified in soil were for a hypothetical future child or hypothetical adult resident and ecological receptors. Two of the three alternatives, S-2 and S-3, provide protection of human health from these risks. Alternative S-1 would not provide a measure to reduce risks to future residents or ecological

Table 13-1
Comparative Analysis of Contaminated Soil Remedial Alternatives Against the Seven Criteria

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Criteria	Alternative S-1 (No Action)	Alternative S-2 (Limited Action)	Alternative S-3 (Excavation and Disposal)
<u>Overall Protection of Human Health and the Environment</u>			
How risks are eliminated, reduced, or controlled.	This alternative would not eliminate, reduce, or control the risk to human receptors.	This alternative would provide an increased level of protection to the environment because risks via direct contact or ingestion of contaminants at the site are minimized by institutional controls.	This alternative would provide an increased level of protection to the environment because risks via direct contact or ingestion of contaminants at the site are eliminated. Worker health and safety requirements would be maintained.
Short-term or cross-media effects.	No short-term or cross-media adverse effects are expected.	No short-term or cross-media adverse effects are expected.	Cross-media contamination may occur during excavation.
<u>Compliance with ARARs/Guidance Material</u>			
Chemical-, location-, and action-specific ARARs.	Would not comply with FDEP SCTLs	Since PSC 51 is in a designated industrial area of NAS Jacksonville, would comply with FDEP soil cleanup target levels.	Would comply with FDEP SCTLs
<u>Long-Term Effectiveness and Permanence</u>			
Magnitude of residual risk	Removal or treatment processes would not be used to address site contamination during the implementation of the no action alternative; therefore, no reduction of risk to the environment would be achieved.	As with the No Action alternative, removal or treatment processes would not be used to address site contamination; however, through limited action, human health risks would be minimized.	The reduction in risk at PSC 51 would be permanent because contaminated soil would be removed and placed in a landfill reducing the exposure to metals.
Adequacy of controls	Implementation of alternative would provide no immediate and long-term source control at PSC 51.	Implementation of alternative would provide immediate and long-term source control at PSC 51, as long as controls remain in-place that would meet RAOs.	Implementation of alternative would provide immediate and long-term source control at PSC 51 that would meet the RAOs for surface soil.
Reliability of controls	No control of contaminants is provided.	Control of contaminants is provided. Institutional controls at NAS Jacksonville and five-year site reviews would be used to assess change in site conditions over time to ensure long-term effectiveness and permanence.	Land disposal is reliable at isolating wastes to prevent migration and exposure but requires maintenance.
<u>Reduction of Mobility, Toxicity, and Volume</u>			
Treatment process and remedy.	Removal, containment, or treatment processes would not be provided.	Removal, containment, or treatment processes would not be provided.	Contaminants would be removed from the site and contained in a permitted facility but not treated.
See notes at end of table.			

Table 13-1 (Continued)
Comparative Analysis of Contaminated Soil Remedial Alternatives Against the Seven Criteria

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Criteria	Alternative S-1 (No Action)	Alternative S-2 (Limited Action)	Alternative S-3 (Excavation and Disposal)
Amount of hazardous material destroyed or treated.	No hazardous material would be destroyed or treated.	No hazardous material would be destroyed or treated.	An estimated 1560 tons of contaminated soil are contained, not treated.
Reduction of Mobility, Toxicity, or Volume through treatment.	No treatment would occur.	No treatment would occur.	No treatment would occur.
Irreversibility of treatment	No treatment would occur.	No treatment would occur.	No treatment would occur.
Type and quantity of treatment residuals.	No treatment residuals would be produced.	No treatment residuals would be produced.	No treatment residuals would be produced.
<u>Short-Term Effectiveness</u>			
Protection of community during remedial action.	No protection of the public would be offered by this alternative.	Protection of the public would be provided through administrative actions. Additional protection not needed as soils remain in place.	Dust control and cross contamination control would be required during soil excavation.
Protection of workers during remedial action.	No remedial action would occur.	No remedial action would occur.	Worker exposure would be more extensive that limited action alternative, and workers would be required to follow an approved Health and Safety Plan.
Environmental Effects.	No adverse environmental effects would be caused.	No adverse environmental effects would be caused.	Releases to air are expected to have minimal effect. Adverse environmental effects would be short term, limited to the time of excavation and site activity.
Time until RAOs and action levels are achieved.	This alternative would not meet RAOs in the near future. RAO may be met after decades of natural remedial processes.	This alternative would meet the RAO as soon as the institutional controls are implemented. Action levels may be met after decades of natural remedial processes.	Approximately 1 month would be necessary to meet the RAOs and action level for PSC 51.
<u>Implementability</u>			
Ability to construct technology.	No construction would be necessary.	Signs materials are readily available.	Materials for excavation, transport, and disposal of soil are readily available.
Reliability of technology	No technology would be required.	Monitoring technology is well developed. Controls are commonly used.	Land disposal reliably reduces migration and exposure.
Ease of undertaking additional remedial action, if necessary.	Would provide no impediment to additional remediation.	Would provide no impediment to additional remediation.	Would provide no impediment to additional remediation.
See notes at end of table.			

Table 13-1 (Continued)
Comparative Analysis of Contaminated Soil Remedial Alternatives Against the Seven Criteria

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Criteria	Alternative S-1 (No Action)	Alternative S-2 (Limited Action)	Alternative S-3 (Excavation and Disposal)
Coordination with other regulatory agencies.	Coordination with USEPA and FDEP necessary.	Coordination with NAS Jacksonville field personnel required. Coordination with USEPA and FDEP necessary.	Coordination with NAS Jacksonville Field personnel required for duration of remedial activities. Coordination with USEPA and FDEP necessary.
Availability and capacity of treatment, storage, and disposal services.	Treatment, storage, and disposal services are not required for this alternative.	Treatment, storage, and disposal services are not required for this alternative.	Availability of permitted treatment, storage, and disposal (TSD) facilities for treatment of contaminated soil would be required at the time of remedial action.
Availability of technologies, equipment, and specialists.	No equipment, services, or personnel required.	Monitoring equipment, services, and personnel are readily available.	Construction contractors, equipment, and laboratories are available.
Costs			
Capital Costs		\$5,000	\$535,000
O&M Costs		\$71,000	\$0
Total Present Worth	No cost was estimated for this option.	\$101,000	\$615,000
Notes: TSD = treatment, storage, and disposal. DOT = Department of Transportation.			

receptors. Alternative S-2 would provide protection to humans and ecological receptors by limiting access, exposure, and institutional controls. Because no standards have been promulgated by USEPA or FDEP for cleanup of soil all three alternatives would comply with ARARs. Since PSC 51 is in a designated industrial area of NAS Jacksonville, Alternative S-2 would comply with FDEP soil cleanup criteria. Alternative S-3 complies with FDEP soil cleanup criteria.

Alternative S-2 complies with RAOs by using institutional controls and site restrictions to minimize exposure. Future human health risks are reduced as long as the institutional controls remain in-place. Alternative S-3 meets the response objectives through removal and off-site containment of contaminants. Alternative S-1 does not comply with RAOs.

13.1.2 Comparison of Primary Balancing Criteria

From a long-term effectiveness and permanence perspective, Alternative S-3 is preferred over Alternatives S-1 and S-2. Alternative S-3 transports the excavated soil across public roads to the off-site disposal facility where containment must be provided indefinitely. However, once completed, all PSC 51 soil would be free of the COPCs.

Alternatives S-3 would take between two and four weeks to complete. Alternative S-2 may require monitoring indefinitely, but as long as the controls remain in-place, Alternative S-2 will provide the same amount of protection as Alternative S-3. Alternative S-1 is currently in use. Alternative S-3 alternative is the most expensive, followed by Alternative S-2, then S-1. No costs were calculated for Alternative S-1.

13.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER

This section presents a comparative analysis of remedial alternatives for groundwater at PSC 51. Section 12.2 detailed the analysis of remedial alternatives for groundwater and focused on the evaluation of alternatives at PSC 51. By approaching the FS in this manner, a logical presentation of the important aspects of each alternative was presented in the detailed analysis (Section 12.0) and the comparative differences between alternatives for PSC 51 are highlighted in the comparative analysis (Subsections 13.3.1).

13.2.1 Comparative Analysis of Remedial Alternatives for Groundwater at PSC 51

Six Alternatives for remediation of groundwater at PSC 51 were evaluated in Section 12.0:

- Alternative GW-1 (no action)
- Alternative GW-2 (monitored NA)

- Alternative GW-3 (enhanced biodegradation)
- Alternative GW-4 (chemical oxidation)
- Alternative GW-5 (extraction-and-treatment)
- Alternative GW-6 (Air Sparging)

The following paragraphs present a comparison between the groundwater alternatives with respect to the seven thresholds and primary balancing criteria.

13.2.2 Comparison of Threshold Criteria

13.2.2.1 Comparison of Threshold Criteria

Overall Protection of Human Health and the Environment. The risk assessment for PSC 51 predicted unacceptable risks to human health associated with contaminants in groundwater for the exposure scenario (groundwater ingestion by hypothetical child, adult, and lifelong resident). All alternatives except Alternative GW-1 provide a measure of protection against possible ingestion of groundwater. The Alternative GW-2 provides only a minimum standard of protection through imposing groundwater use restrictions.

Alternative GW-3, Alternative GW-4, and Alternative GW-6 use in-situ treatment methods to remediate PSC 51 groundwater. Based on the natural degradation of VOCs in the PSC 51 groundwater and published experience (Regenesis) with the use of oxygen-releasing compound to remediate VOCs, it is assumed that Alternative GW-3 would effectively destroy VOCs in the surficial aquifer. Alternative GW-4 is expected to effectively mix oxidant with contaminated groundwater, thus oxidizing VOCs in-situ. The Alternative GW-5 and Alternative GW-6 provide aggressive means to directly remove VOCs from the aquifer. The potential treatment technologies for Alternative GW-5 and Alternative GW-6 are proven methods although over the long term.

The reduction in VOCs offered by alternatives GW-2, GW-3, GW-4, GW-5, and GW-6 are expected to achieve RAOs. Combined with implementation of groundwater use restrictions and surface water monitoring until RAOs have been achieved, these alternatives would be protective of human health.

Compliance with ARARs. The Alternative GW-1 and Alternative GW-2 would not comply with chemical-specific ARARs in the short term. The Alternative GW-2 would eventually comply with ARARs if the unassisted natural transformation processes continue. The Alternative GW-1 may eventually comply with ARARs. Alternatives GW-3, GW-4, GW-5, and GW-6 would achieve RAOs through destruction of VOCs by biological, chemical, and mechanical mechanisms. Alternatives GW-2, GW-3, GW-4, GW-5, and GW-6 would comply with location- and action-specific ARARs.

13.2.2.2 Comparison of Primary Balancing Criteria

Long-Term Effectiveness and Permanence. The Alternative GW-1 would not provide a means of exposure control. Groundwater use restrictions imposed under the Alternative GW-2 would provide a means of exposure control until RAOs are achieved. The Alternatives GW-3 and GW-4 for PSC 51 groundwater are expected to achieve treatment levels at five years for Alternative GW-3 and two years for Alternative GW-4. The Alternatives GW-6 and GW-5 are expected to achieve treatment levels within five and eight years, respectively. The Alternatives GW-2, GW-3, GW-4, GW-5, and GW-6 reduce VOCs permanently and irreversibly such that no controls (administrative or physical) of residual risk would be required.

Reduction of Toxicity, Mobility, and Volume through Treatment. Unassisted biodegradation (Alternatives GW-1 and GW-2) of VOCs in the aquifer has already been occurring, and the toxicity, and volume of contaminants would likely continue over time. The Alternatives GW-1, GW-2, and GW-3 would not reduce contaminant mobility. The estimated duration of treatment for Alternative GW-3 is expected to be five years and therefore some migration of the plume is likely during implementation of this alternative.

The Alternatives GW-4, GW-5, and GW-6 would provide a reduction in toxicity, mobility, and volume of contaminants. GW-4 would provide chemical destruction of VOCs in-situ, reducing toxicity, mobility, and volume. Alternative GW-5 method, by extracting groundwater from the plume, would control the hydraulic flow paths, preventing contaminant migration, while reducing toxicity, and volume. Alternative Alternative GW-6 would intersect the hydraulic flow paths preventing contaminant migration while reducing toxicity, mobility, and volume.

The only treatment residuals produced by implementation of evaluated remedial alternatives at PSC 51 are spent packing material for Alternative GW-5.

Short-Term Effectiveness. All alternatives for PSC 51, except GW-1, include groundwater use restrictions to protect future receptors from ingesting groundwater during remedial implementation. Ongoing natural transformation processes in the aquifer work over a long-term time period. Therefore, the Alternative GW-1 would not achieve RAOs in the short term. The Alternatives GW-2, GW-3, GW-5, GW-6, and GW-4 varying times to achieve RAOs. It was estimated that Alternative GW-2 would achieve RAOs after 15 years, Alternative GW-3 would achieve RAOs after five years, Alternative GW-4 would achieve RAOs in two years, Alternative GW-5 in eight years, and Alternative GW-6 approximately five years.

Implementability. The Alternative GW-1 is the easiest to implement because it is the alternative that is in place at this time. The Alternative GW-2 is easy to implement because it includes only groundwater

monitoring and reporting, groundwater use restrictions, and five-year site reviews. The Alternatives GW-3 and GW-4 are relatively easy to implement through use of subcontractors who specialize in these types remedial actions. A pilot test would be conducted to determine the extent of application of the two alternatives. Both of these alternatives require injection of chemical compounds into the aquifer through wells or DPT.

The Alternatives GW-5 and GW-6 require construction of remediation systems with aboveground equipment for groundwater treatment. The Alternatives GW-5 and possibly the Alternative GW-6 would require a pilot-test to determine the effectiveness for VOC removal prior to selection as a remedial alternative. The Alternative GW-5 and GW-6 would require construction of equipment onsite. Extraction wells and sparge points would also be required, with the number of wells and sparge points to be determined after the pilot study has been conducted for the respective alternatives. It is anticipated that these alternatives would be more difficult to implement due to the more intensive construction and O&M requirements.

Cost. Table 13-2 presents a comparison of the present worth costs estimated for remedial alternatives that could be used to treat the VOC-contaminated groundwater at PSC 51. Where applicable, these present worth costs include direct and indirect capital costs, system O&M, system and groundwater monitoring to ensure performance, monitoring of the groundwater plume, and five-year site reviews. Table 13-2 also indicates the treatment duration for each alternative, representing the number of years for completion of remedial activities.

The cost estimates incorporated treatment duration's based on site-specific hydrogeologic characteristics at PSC 51. It was assumed that five-year site reviews would be conducted to encompass the expected treatment duration and therefore present worth costs for each alternative includes performance of site reviews every five years until RAOs have been achieved. A fixed alternative duration of 30 years (USEPA, 1988) was used only when an indefinite time was required to achieve the RAOs. This condition applied to the Alternatives GW-1.

As expected, the Alternative GW-1 has the lowest present worth cost of \$0. The Alternative GW-2 was the second lowest cost at \$384,000. The in-situ treatment Alternatives GW-3 and GW-4 had present worth costs of \$600,000 and \$813,000, respectively. The Alternative GW-5's cost is \$1,003,000, and Alternative GW-6 has a cost of \$736,000.

13.2.2.3 Summary and Recommendations

Table 13-2 presents a summary of the comparative analysis for the PSC 51 groundwater alternatives.

Table 13-2
Comparative Analysis Summary of Groundwater Alternatives

Remedial Investigation/Feasibility Study for PSC 51
Naval Air Station Jacksonville
Jacksonville, Florida

Alternative:	GW-1 No Action	GW-2 NA	GW-3 Enhanced Biodegradation	GW-4 Chemical Oxidation	GW-5 Extraction- and-Treatment	GW-6 Air Sparging
Groundwater Remediation						
Groundwater Extracted?	No	No	No	No	Yes	No
Organics reduced?	Yes	Yes	Yes	Yes	Yes	Yes
Estimated time to achieve action levels?	30 years ¹	15 Years	5 years	2 year	8 years	5 Years
Plume contained?	No	No	No	Yes	Yes	Yes
Plume toxicity reduced?	Yes	Yes	Yes	Yes	Yes	Yes
Remedy Permanent?	Yes	Yes	Yes	Yes	Yes	Yes
Treatment Residuals produced?	No	No	No	No	Yes	No
Operation and Maintenance (O&M)						
Estimated duration of O&M activities?	30 Years ¹	15 Years	5 Years	2 years	9 years	5 years
Utilities maintenance?	No	No	No	No	Yes	Yes
Groundwater monitoring?	No	Yes	Yes	Yes	Yes	Yes
Total Cost						
Present worth	\$0	\$384,000	\$600,000	\$813,000	\$1,003,000	\$736,000
1 An implementation time of 30 years was used for the no action alternative, based on U.S. Environmental Protection Agency (USEPA) guidance (USEPA, 1988).						

PSC 51 does not currently provide a significant ecological habitat, and the area is contained within a controlled location within NAS Jacksonville, which limits human exposure. Additionally, there is no current land use at PSC 51, and given the location of the PSC within the boundaries of NAS Jacksonville, future land use scenarios are expected to remain the same or industrial in nature. The surface soil sample results at the site represent a general contaminant level between residential and industrial SCTLs. With the controlled access at PSC 51 and the LUCIP Program currently in place at NAS Jacksonville, it is

expected that the proposed actions of Alternative S-2 will be sufficient for the protection of human health. The remedial actions involved with Alternative S-3 would remove the contaminated soil at PSC 51 and, therefore, remove all potential human health risks associated with the site, however the contaminated soil would be removed to a landfill with monitoring and restrictions similar in nature to the restrictions proposed in Alternative S-2. Therefore, to meet the RAO for surface soil in the most cost-effective fashion, Alternative S-2 is recommended. Should the land use change to a residential scenario in the future, alternative remedial technologies such as Alternative S-3 should be considered.

Groundwater at PSC 51 is contaminated with organics above regulatory criteria (GCTLs), and presents a potential human health hazard. The ERA determined uncertainty as to whether or not the groundwater to surface water (unnamed creek) pathway was complete. All groundwater alternatives (other than the no action alternative) include monitoring of surface water to assure surface water is not impacted above regulatory criteria or become an ecological risk. The total mass of contaminants adsorbed and dissolved in the aquifer at PSC 51 was determined to be small (approximately 13 lbs) and the concentrations relatively low. In addition, the small creek located to the south of the PSC appears to drain water from the area and provide a control for off-site migration of contaminants. It is expected that all groundwater alternatives (other than the no action alternative) will result in a reduction of groundwater contaminants at PSC 51. With the surface water monitoring and land use controls proposed with each alternative, all groundwater alternatives will protect human health and reduce contaminant concentrations over time. As a result, cost and effectiveness are proposed as the deciding factors for the selected remedial alternative. Groundwater alternatives with active remediation and O&M (such as GW-4, GW-5, and GW-6) will provide a reduction of contaminants in a shorter time, but at a higher cost and with the same result as the other groundwater alternatives. NA has been evaluated at PSC 51, and appears to be an effective alternative for the site. In addition, with the monitoring proposed with alternative GW-2, if it is determined in the future that NA has become ineffective another alternative such as GW-3 could be proposed to enhance the degradation of contaminants at PSC 51. Therefore, Alternative GW-2 is recommend as a feasible and cost effective alternative for remediation of the groundwater at PSC 51.

13.2.2.4 Contingency Actions

This FS considers the following two potential scenarios where contingent actions may be required:

1. Monitored natural attenuation is ineffective at reducing the groundwater contamination in the predicted timeframe.

To track the remedial progress of Groundwater Alternative GW-2 at PSC 51, Annual Milestone Objectives were established for COCs to attain PRGs within 10 years for non-chlorinated VOCs, and 15 years for

chlorinated VOCs. The Milestone Objectives were established for each COC using the FDEP Milestone Objective Software Program using linear regression. The milestones are listed in Table 13-3.

The Milestone Objectives will be reviewed during the five-year reviews to determine if contingency actions are necessary in the event that natural attenuation is not performing adequately. If it is determined that natural attenuation is not effectively remediating the groundwater, oxygen releasing compound[®] injection as presented in Groundwater Alternative GW-3 will be implemented to increase the degradation of COCs in groundwater.

If the results of a five-year review show that natural attenuation is not adequately performing to remediate groundwater contamination, active remedial measures will be implemented. Contingency measures for groundwater in this case will involve enhanced biodegradation via ORC[®] as presented in this FS as groundwater alternative GW-3. In this case a remedial design shall be prepared and implemented to remediate the contaminated groundwater plume.

2. Concentrations of contaminants in the surface water exceed the RAOs for surface water.

If it is determined during the groundwater and surface water monitoring at PSC 51 that the groundwater COCs have impacted the unnamed creek south of PSC 51 and are present at concentrations above surface water PRGs listed in Section 10.2.2.1, a contingency action will occur. Specifically, the groundwater plume will be treated via oxygen releasing compound[®] injection as presented in Groundwater Alternative GW-3.

REFERENCES

ABB-ES (ABB Environmental Services), 1995a. Naval Installation Restoration Program Plan, Volume 7, Remedial Investigation and Feasibility Study Work and Project Management Plan, Operable Unit 3 (OU3), NAS Jacksonville, Jacksonville, Florida. Prepared for Southern Division Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), North Charleston, South Carolina, (March).

ABB-ES, 1995b. Naval Installation Restoration Program Plan, Volume 2, Remedial Response Decision System, NAS Jacksonville, Jacksonville, Florida. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

ABB-ES, 1996. Remedial Investigation and Feasibility Study, OU-1, NAS Jacksonville, Jacksonville, Florida. Prepared for SOUTHNAVFACEMCON, North Charleston, South Carolina, (March).

ABB-ES, 1997. Naval Installation Restoration Program Plan, Naval Air Station, Jacksonville, Florida, Volume 3, Site Screening Workplan. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

AFCEE (Air Force Center for Environmental Excellence), 1996. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*. Draft-Revision 1. San Antonio, Texas.

Amdur, M.O., J. Doull, C.D. Klassen eds., 1991. Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd edition. Macmillan Press, New York, New York.

ATSDR (Agency for Toxic Substances and Disease Registry), 1988. *Toxicological Profile for Arsenic*. U.S. Department of Health and Human Services, Public Health Service.

BEI (Bechtel Environmental, Inc.), 1999. *Completion Report for the PSC 51 South Antenna Area, NAS Jacksonville, Jacksonville, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

Clarkson, Thomas W., 1983. "Molecular Targets of Metal Toxicity" in Chemical Toxicology and Clinical Chemistry of Metals. Academic Press, Inc. Orlando, Florida.

Davis, J. Hal, 1996. *Simulation of Ground-Water Flow at the U.S. Naval Air Station Jacksonville, Florida, with an Evaluation of the Changes to Ground-Water Movement Caused by Proposed Remedial Designs at Operable Unit 1*. Open File 96-597. USGS.

Davis H.J., 1998. *Ground-water Hydrology and Simulation of Ground-water Flow at Operable unit 3 and Surrounding Region, U.S. Naval Air Station Jacksonville, Florida*: USGS Open File Report 98-68, 36p.

Eisler, R., 1987. *Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*. U.S. Fish and Wildlife Service. Biological Reports 85(1.11).

Eisler, R., 1988. *Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*, Contaminant Hazard Reviews, Report No. 14, Biological Report 85(1.14), United States Fish and Wildlife Service, Laurel, MD, April. (cos)

Fairchild, R.W., 1972. *The Shallow-Aquifer System in Duval County, Florida*: Florida Bureau of Geology Report of Investigation No. 59.

Fairchild, R.W., 1977. *Availability of Water in the Floridian Aquifer in Southern Duval and Northern Clay and St. Johns Counties, Florida*: U.S. Geological Survey Water – Resources Investigation 76-98, prepared in cooperation with the City of Jacksonville, Public Works Department.

FDEP (Florida Department of Environmental Protection), 1999. *Contaminant Clean-up Target Levels FAC. 62-770*, Florida Department of Environmental Protection, August 5, 1999.

Freeze, R. Allan and Cherry, John A., 1979. *Groundwater*.

HLA (Harding Lawson Associates), 1999a. *Sampling Event Report, Potential Source of Contamination South Antenna Field Fire Fighting Training Area, NAS Jacksonville, Jacksonville, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

HLA, 1999b. *Remedial Investigation and Feasibility Study Operable Unit 3, Naval Air Station Jacksonville, Jacksonville, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

HLA, 2000. *Remedial Investigation and Feasibility Study Operable Unit 3, NAS Jacksonville, Jacksonville, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

HSDB (Hazardous Substance Data Base), 2002. Electronic data base available on TOXNET from the National Library of Medicine at <http://toxnet.nlm.nih.gov>.

Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese, and W. Basham, 1997. *Environmental Contaminants Encyclopedia*. National Park Service, Water Resources Division, Fort Collins, Colorado. Distributed on the Internet via the Nature Net portion of the Park Service Home Page (www.nps.gov), 1998. Also distributed by the NPS and/or NTIS via CD-ROM.

Johnson, R.L., P.C. Johnson, P.B. Mcwhorther, R.E. Hinchee, and I. Goodman. 1993. "An Overview of In-Situ Air Sparging," Groundwater Monitoring Review, Fall 1993.

Leve, G.W., 1966. *Groundwater in Duval and Nassau Counties, Florida*: Bureau of Geology Report of Investigation No. 43.

MVROM (Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer), 2000. Circular on target values and intervention values for soil remediation. MVROM (Ministry of Housing, Spatial Planning, and Environment), Directorate-General for Environmental Protection, Department of Soil Protection, The Hague, The Netherlands. February.

NAS Jacksonville, 1990. *FFA Site Management Plan*: November 14.

Sample, B.E., D. M. Opresko, and G. W. Suter II, 1996. *Toxicological Benchmarks for Wildlife, 1996 Revision*. Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Scott, T.M., 1988. *The Lithostratigraphy of the Hawthorn Group (Miocene) of Florida*: Florida Geological Survey Bulletin No. 59.

Suter, G.W., and C.L. Tsao, 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota*: 1996 Revision. ES/ER/TM-96/R2. June.

Toth, D.J., 1990. *Geohydrologic Summary of the Floridian Aquifer in Coastal Areas of Nassau, Duval, and Northern St. Johns Counties*: St. Johns River Water Management District Technical Publication SJ 90-5, Palatka, Florida.

TtNUS (Tetra Tech NUS, Inc.), 1999a. *Remedial Investigation/Feasibility Study Field Sampling Plan for Potential Source of Contamination 51, Naval Air Station Jacksonville, Jacksonville Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

TtNUS, 1999b. *Remedial Action Plan for Former Fire Fighting Training Facility at NAS Jacksonville, Jacksonville, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

TtNUS, 2001. *Remedial Investigation/Feasibility Study Field Sampling Plan and Quality Assurance Project Plan Addendum for Potential Source of Contamination 51*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina. July.

USDA (United States Department of Agriculture), 1978. *Soil Survey of Duval County, Florida*.

USEPA (United States Environmental Protection Agency), 1979. *The Health and Environmental Impacts of Lead and an Assessment of a Need for Limitations*. USEPA Report 560/2-79-001.

USEPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final*. USEPA/540/G-89/004. Office of Solid Waste and Emergency Response (OSWER), Washington D.C. October.

USEPA, 1989. *Risk Assessment Guidance of Superfund (RAGS)*. USEPA 540/1-89/002. December.

USEPA, 1991. *Risk Assessment Guidance for Superfund - Volume I - Human Health Evaluation Manual - Supplemental Guidance - Standard Default Exposure Factors (Interim Final)*. OSWER Directive 9285.6-03. March.

USEPA, 1992. *In-situ Bioremediation of Contaminated Ground Water*. USEPA/540/S-92/003.

USEPA, 1992b. *Dermal Exposure Assessment and Principles and Applications*. USEPA/600/8-91/011B. January.

USEPA. 1992c. *Supplemental Guidance to RAGS: Calculating the Concentration Term*. OSWER Publication No. 9285.7-081, Washington, D.C. May.

USEPA, 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

USEPA 1994/1999 revised. *USEPA National Functional Guidelines for Inorganic and Organic Data Review*. February.

USEPA, 1995a. Final Water Quality Guidance for the Great Lakes System; Final Rule. Federal Register Vol. 60, No. 56, Thursday, March 23, 1995, pg. 15366-15425.

USEPA, 1995b. *Supplemental Guidance to RAGS: Region IV Bulletins, Ecological Risk Assessment Bulletin No. 1-4*. Region IV, Atlanta, GA.

USEPA, 1996a. *Soil Screening Level Guidance: Technical Background Document*. Office of Emergency and Remedial Response, Washington, D.C. May.

USEPA, 1996b. *EPA Region IV Dermal Risk Values Derived by Calculation from Gastrointestinal (GI) Absorption Data in Chemical Order*. February.

USEPA, 1997a. *Health Effects Assessment Summary Tables FY 1997*. Office of Solid Waste and Emergency Response, Washington, D.C. July.

USEPA, 1997b. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Edison, New Jersey. June.

USEPA, 1998a. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*. Office of Research and Development, Washington D.C.; USEPA/600/R-98/128. September.

USEPA, 1998b. *Risk Assessment Guidance for Superfund: Volume I. Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments)*, Interim. Publication 9285.7-01D. January.

USEPA, 2000a. *Risk-Based Concentration Table*. Region III, Philadelphia, PA. April.

USEPA, 2000b. *Integrated Risk Information System (IRIS) On-line Data Base*. May.

USEPA, 2000c. *Ecological Soil Screening Level Guidance (Draft)*, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

USGS (United States Geological Survey), 1993. *Orange Park Quadrangle, Florida, 7.5 Minute Series (Topographic)*. United States Department of the Interior Geological Survey.

Venugopal, B. and T. D. Luckey, 1978. *Metal Toxicity in Mammals. Volume 2. Chemical Toxicity of Metals and Metalloids*, Plenum Press, New York, NY.

Williams, G.M. and J.H. Weisburger, 1991. "Chemical Carcinogenesis," in M.O. Amdur, J. Doull, and C.D. Klaassen, eds., Cassarett and Doull's Toxicology, the Basis Science of Poisons, 4th Edition, Pergamon Press, New York, NY.